Andreas Roth

Orthopedic and Trauma Findings

Examination Techniques, Clinical Evaluation, Clinical Presentation

Translated by
Gustav F. Preller

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Dedicated to Antje, Johannes and Maria

Foreword

The goal of medical education is to scientifically and practically train doctors to be able to responsibly and independently practice medicine, to keep on learning, and to always critically examine their actions. Medical schools need to teach basic knowledge and skills on all medical subjects required to guarantee health care for a broad population. Many medical societies are rightfully questioning whether medical graduates are sufficiently skilled in orthopedics and trauma surgery.

The economic impact of disease and disorders related to orthopedics and trauma surgery has been sufficiently proven by medical insurance and pension fund statistics. Degenerative disorders of the musculoskeletal system are widespread. Although accident-related injuries have been declining slightly, there has been a rise in fractures among elderly patients that are associated with various medical and social repercussions. Intensifying student training in orthopedics and trauma surgery is thus highly relevant in our times. Subject-specific training often suffers under modern educational practice, favoring broad, interdisciplinary training. This negatively impacts not only students who want to pursue a career in orthopedics and trauma surgery but also students aiming for a career in general medicine, a discipline that deals with many orthopedic disorders. American studies have found that general practitioners find their training in orthopedics inadequate for providing their patients with the health care they require. Many general practitioners do not possess enough special orthopedic physical examination skills. One study found that only 6 % of chronic knee injuries involving cruciate ligament tears were discovered by primary care physicians. Further studies have shown that only 10 % of patients on orthopedic and trauma surgery wards received adequate physical examinations—even though they complained of problems involving the musculoskeletal system.

Considering the high prevalence of disorders and injuries of the musculoskeletal organs requiring medical care, doctors with competence in this field are crucially needed. The knowledge required for this competence is the subject of this book. With a focus on orthopedics, this book discusses disorders of the spine, the upper extremity, and the lower extremity in separate chapters. General findings and leading symptoms are used to introduce the disorders of these regions. An emphasis is placed on the examination techniques for the specific bodily regions. In this emphasis lies the value of this book: it is an introduction but also a reference for those not specialized in the field but who are confronted with orthopedic disorders on a daily basis. This book is thus ideal not only for students wishing to acquire knowledge of orthopedics but also for graduates training to be general practitioners. Many figures excellently visualize the required examination techniques.

In the specific part, various orthopedic and trauma surgery disorders are discussed, classified as clinical, neurological, congenital, degenerative, inflammatory, and tumor disorders. As the title already suggests, the focus remains on the clinical findings. Patient history, physical examination, diagnostics, and differential diagnosis are briefly discussed with keywords. What treatment should be selected and the therapeutic options are not discussed in this book. This is an important book. I believe it belongs in every practice.

The current political emphasis on primary health care instead of specialized care—combined with the current skills shortage in orthopedics and trauma surgery—raises fears that patients may not be receiving the health care they need. This book makes an important progress: it bridges the gap between specialized orthopedics and general medicine.

Fritz Uwe Niethard
Aachen, Germany
June 2015

Preface

A precise patient history and a thorough physical examination remain the simplest methods to diagnose disorders of the musculoskeletal system. They form the prerequisites for further diagnostic tests that ultimately determine what therapy options are chosen.

This book discusses patient history and physical examination of the singular regions of the musculoskeletal system systematically. Physical examinations are photographically depicted. Tables containing the most important leading symptoms enable a quick differential diagnosis for selected clinical pictures, drawing from typical patient history and physical examination findings. For all disorders, attention is drawn to further diagnostics and possible differential diagnoses that need to be considered.

Although there is a trend toward specialization in orthopedics and trauma surgery today, both younger and more experienced colleagues require knowledge on the physical examination and diagnostics of the musculoskeletal system. This book not only serves student education and the education of those specializing in orthopedics but also serves as a reference for private practitioners and doctors working in acute clinics or in rehabilitation clinics.

I would like to thank all who took part in this project for their hard work, their involvement, and their enthusiasm. I would like to thank Professor Milan Handl from Prague and Dr. Long Xin from Hangzhou for their collaboration in collecting the photographic depictions. Special thanks to Prof. Milan Handl, who translated the first edition of this book into Czech and published the book in the Czech Republic. I thank Gustav Ferdinand Preller, from South Africa, who translated the book into English; Mr. Hardi Hauk from Lichtenstein for rendering the images and archival work in the Rudolf-Elle-Hospital in Eisenberg; and Ms. Angela Steller from Leipzig, who helped collect images of clinical findings from the archive of the University Clinic of Leipzig. I thank all my colleagues as well as heads of department who helped me in collecting images for this book. A further thank you to the medical students Marie Winkler and Peter Melcher from Leipzig and Ms. Martina Maresova from Prague who acted as models to demonstrate the examination techniques. Thank you as well to the artist Mario Thieme from Eisenberg for the drawings that complete this book.

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Andreas Roth
Leipzig, Germany
July 2016

Contents

Spine

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1.1 History

1.1.1 Localization and Nature of Complaint

Pain	Localization	Circumscribed/radiating
	Character	Numb/sharp/drilling/throbbing/burning/cramp-like
	Situation	During certain movements, underload/at rest, elicited by sneezing, coughing, pressing, at night
Swelling	Location/extent	
Deformity	Location/kind	Altered posture, deformity
Movement disorder	Location/kind/direction	Limitation of movement/locking/stiffness, walking distance
Sensory disorder	Location	Paresthesia/numbness/tingling/pins and needles
Motor disorder	Location/degree (extent)	Muscular atrophy
		Uncertain gait/coordination disorders
	Location/degree (M5–M0[a])	Weakness/paralysis/spasticity
	Vertigo (cervical spine)	Rotating vertigo, lift vertigo
	Motor function (cervical spine)	Swallowing disorders
		Arm raise/lowering
		Elbow flexion and extension
		Making a fist/finger extension
	Motor function (thoracic/lumbar spine)	Hip flexion/extension, abduction/adduction
		Knee flexion/extension
		Foot raise/lowering
		Bladder and rectal dysfunction

[a]Janda's muscle strength test:
Level 5: Full movement, normal strength
Level 4: Movement possible against some resistance
Level 3: Movement possible against gravity
Level 2: Movement possible with aid, but not against gravity
Level 1: Only some muscle twitching
Level 0: No muscle twitching

1.1.2 Time Correlations

Beginning and course	Congenital/acquired (age/point in time)
	Acute/chronic
	Slowly/stably progressive
	Occurrence in flares with or without symptom-free intervals
	During the day/at night

1.1.3 Concomitant Circumstances

Accident	Yes/no	
Location	Leisure/workplace	
Mechanism of injury	Kind	Working overhead/lifting a load/heavy lifting/accident
	Triggering event	No triggering event/fall/bending/rising from a squatting position
		Height/weight/load/persons involved
	Motor vehicle accident	Type of vehicles involved/direction/speed, angle of impact, lateral, head-on or rear-end collision, head impact/headrest/safety belts
Pre-existing conditions	Family medical history	
	Degenerative/bacteria/rheumatic inflammatory	No/if yes: local/systemic
	Bacterial infection/viral infection	
	Traumatic/tumor	
	Malformations	
Common symptoms	Fever, weight loss (time period of weight loss), fatigue, nocturnal sweating	Yes/no

1.1.4 Existing Treatment/Past Treatment

Drugs	Medication/dose/duration of intake	Localized/systemic
	Relief	Yes/no
Physical therapy	Application	Forms/duration/frequency
	Relief	Yes/no
Orthopedic aids	Walking stick/crutches	Yes/no
	Basques/bandage	
	Brace/cast	
Operations	Time/site/type/success	

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1.2 Cervical Spine

1.2.1 Systematic Examination

- **Local findings**

Deviation from perpendicular line	Steep/overhang	Right/left
Axis/position	Facial scoliosis	None; right/left convex
	Torticollis	None; right/left
Lordosis	Normal/flattened/kyphosed/ prominence processus spinosus C7	
Shoulder position	Shoulder on equal level/elevated shoulder	Right/left
Swelling/redness/heat	No; if present, then:	Localization/extent/scope
Hematoma/abrasion/ open wound/scab	No; if present, then:	Localization/extent/scope
Scarring	No; if present then:	Localization/extent (soft/rough/displaced)
Muscles	Paravertebral muscles	Highly developed/wasted/shortened
	Shoulder and neck muscles	Atrophy (significant?), myogelosis/muscle tone increase or decrease
Mobility	Chin–sternal notch distance: at anteflexion/at reclination	--cm/--cm
	Sideways tilting	––/––/–– degrees
	Rotation	In neutral position (0 position) ––/––/–– degrees
		In anteflexion ––/––/–– degrees
		In reclination ––/––/–– degrees
Tenderness	None; if present:	Suboccipital/spinous/interspinous/ paravertebral (level; right/left)
Tenderness upon striking	None; if present:	Level: spinous/interspinous
Compression pain	Yes/no	
Traction test	With pain relief/without pain relief	

- **Neurology**

Horner's triad	Absent/present	Right/left
Deep tendon reflexes	Biceps (C5) Triceps (C7) Brachioradialis (C6)	Right/left Vigorous/decreased/absent/ supernormal (hyperreflexic)
Sensory examination	Dermatome (segment assignable/ not exactly assignable)	Hypesthesia/paresthesia/dysesthesia

Motor function examination	Shoulder abduction (C5/6) Elbow flexion (C5/6) Elbow extension (C7) Pronation (C6–Th1) Supination (C5/6) Wrist extension (C6/7) Wrist flexion (C6–Th1)	Right/left intact/impaired function (M0–M1–M2–M3–M4–M5)

- **Circulation**

Arteries	Radial artery	Fully/barely/not palpable (right/left)
	Vertebral artery: de Kleijn test	Negative/positive (right/left)
	Carotid arteries: Adson test	Negative/positive (right/left)
Veins	Venous stasis	Present/absent (right/left)
Capillary pulse	Fingertips	Visible/invisible

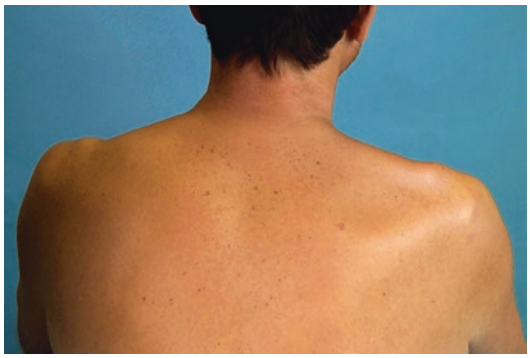


Fig. 1.1 The clinician must look for any deviation from the imagined perpendicular line or asymmetry in the cervical spine. Clinical inspection also involves looking for possible muscle atrophy of the shoulder, neck, and paravertebral muscles. This figure illustrates atrophy of the right supraspinatus muscle

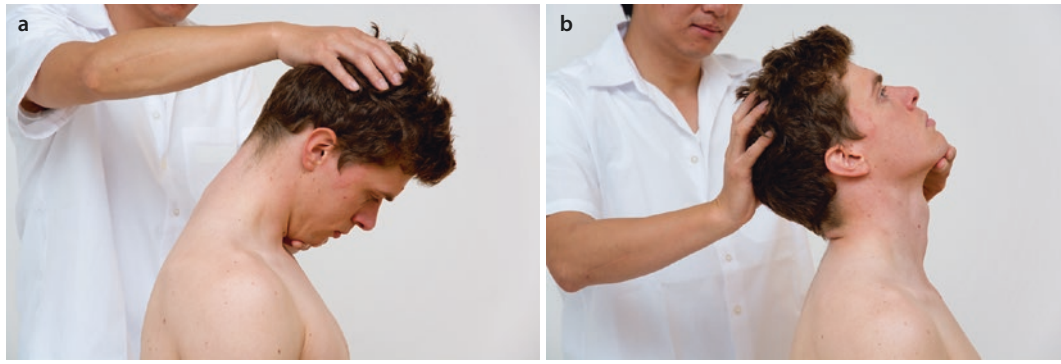


Fig. 1.2 (**a**, **b**) Testing the mobility of the cervical spine for anteversion (**a**) and retroversion. (**b**) (Normal values 35–45/0/35–45°). Alternatively, the values are recorded in cm between the chin and the sternal notch at maximal anteflexion (**a**) and maximal retroflexion (**b**)

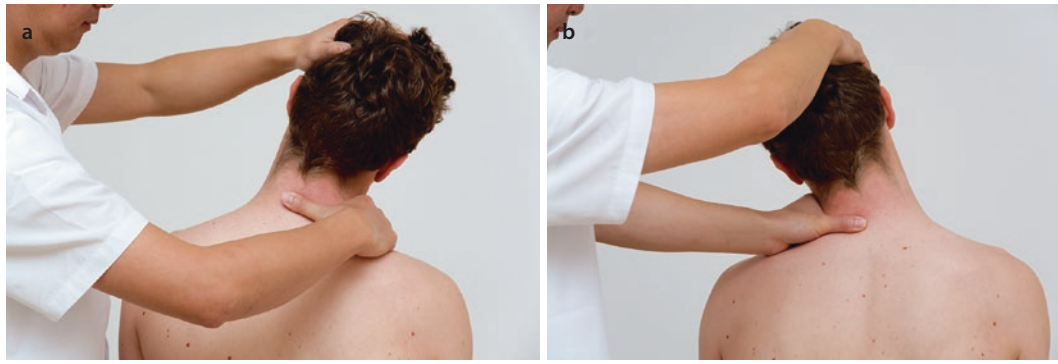


Fig. 1.3 (**a**, **b**) Testing the sideways tilt of the cervical spine. (**a**, **b**) Normal values right/left 45/0/45°

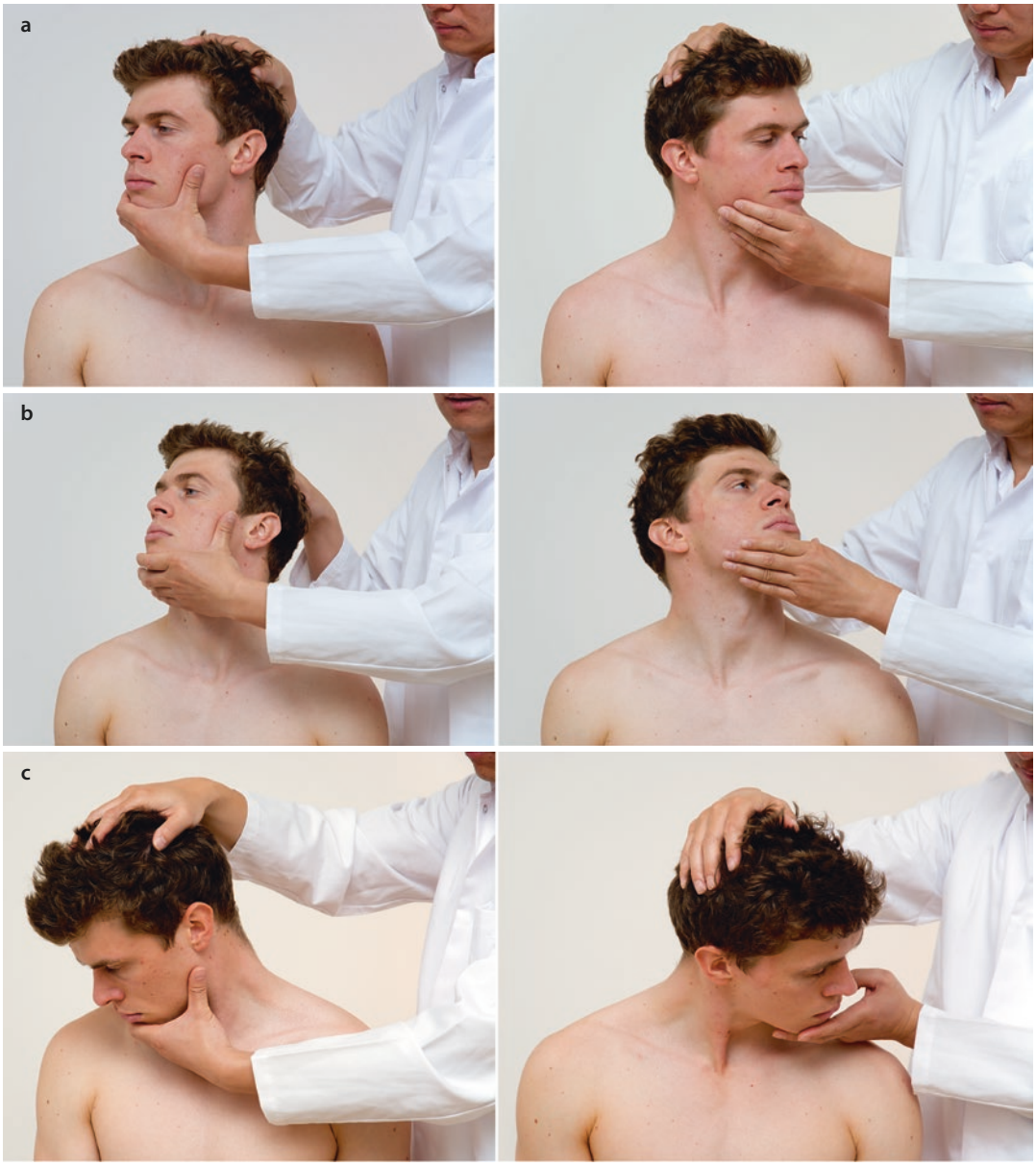


Fig. 1.4 (**a**–**c**) Rotation of the cervical spine in neutral position (**a**), maximum retroflexion (**b,** concerns the lower cervical spine) anteflexion (**c,** concerns the upper cervical spine). Normal values for rotatory range of motion of the cervical spine: right/left, 60–80/0/60–80°

Fig. 1.5 Testing tenderness to pressure in the cervical spine (compression test)

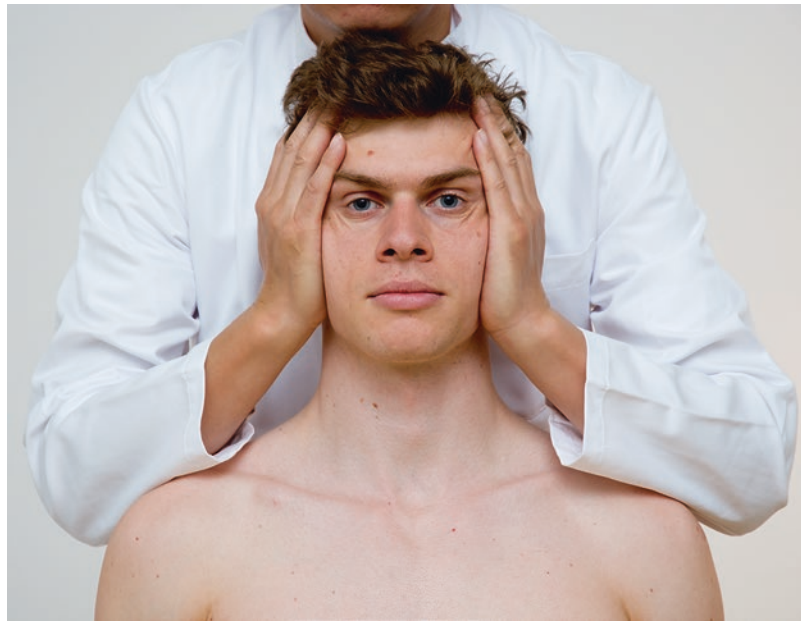
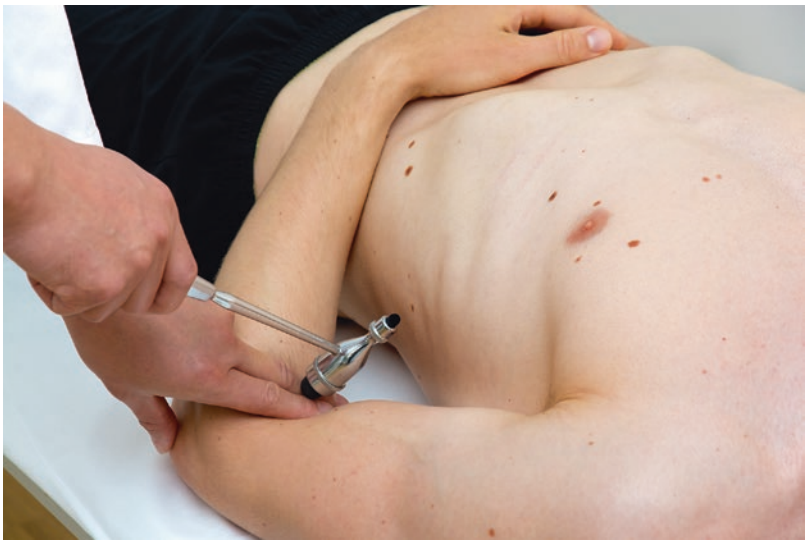


Fig. 1.6 Traction test of the cervical spine (with or without pain relief)

Fig. 1.7 Horner's triad left: ptosis, miosis, and enophthalmus. Horner's triad can accompany a Pancoast tumor, lower plexus paralysis (Klumpke), and injuries of the thoracic and cervical spine

Fig. 1.8 Testing the biceps reflex. The arm is slightly flexed, and the examiner hits his own fingers placed on the distal biceps tendon with the reflex hammer



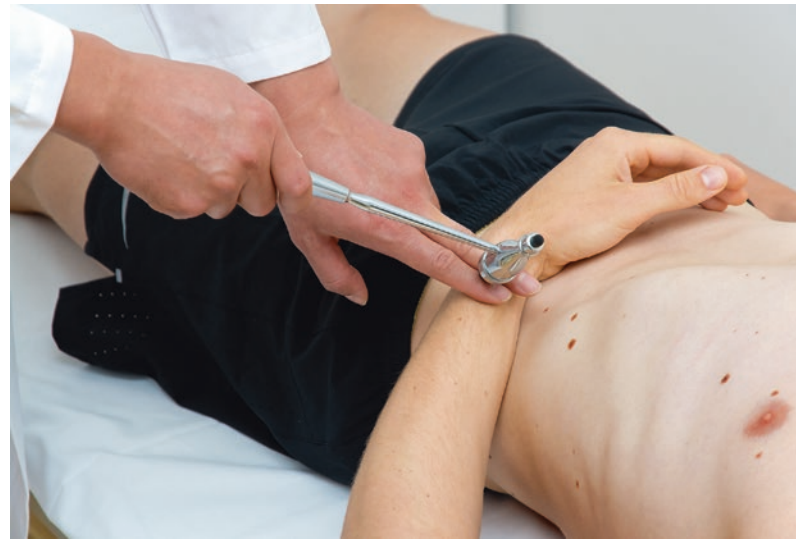


Fig. 1.9 Testing the brachioradialis reflex

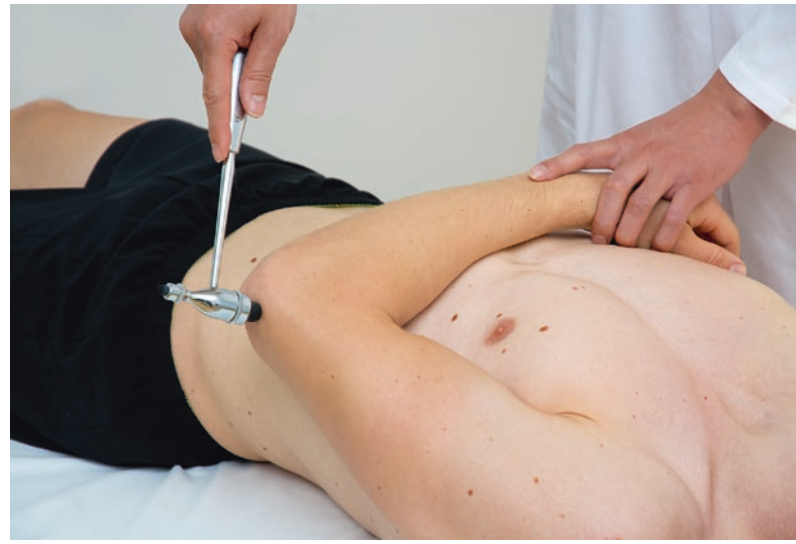


Fig. 1.10 Testing the triceps reflex

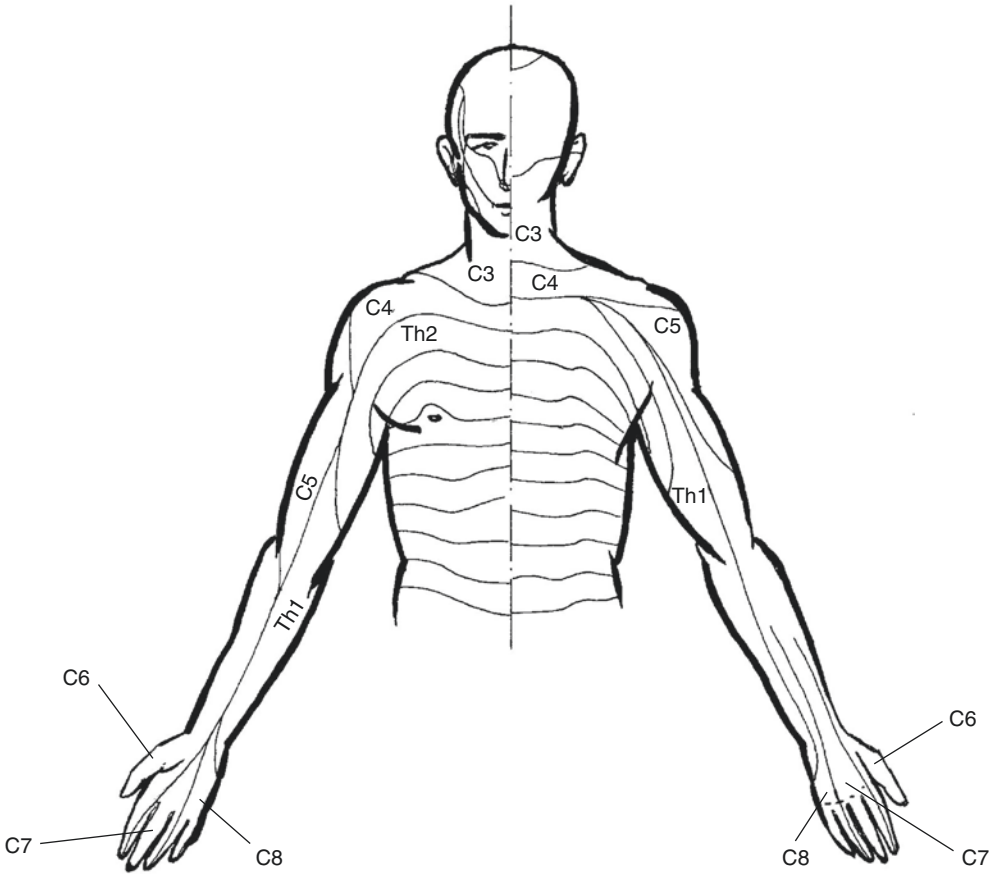


Fig. 1.11 Segmental, sensory innervation of the upper limbs and the trunk (ventral and dorsal)

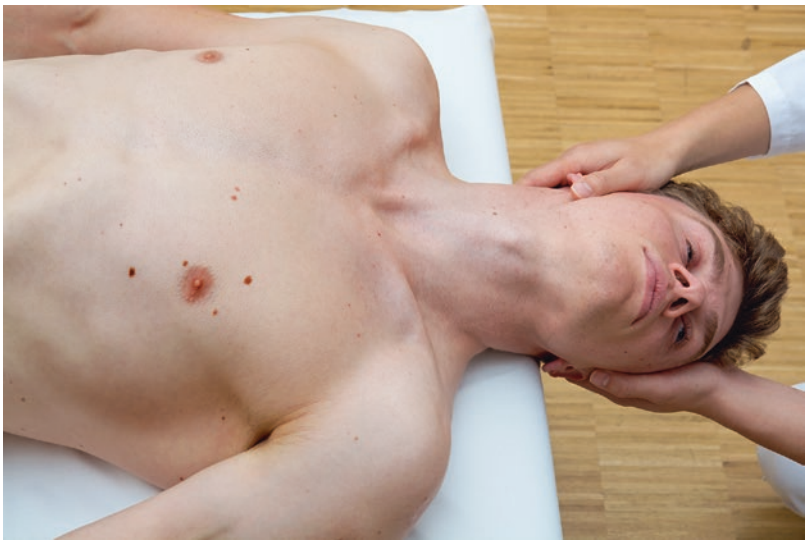


Fig. 1.12 De Kleijn test: patient lies prone on the examination table. Passive retroflexion, tilt, and rotation of the cervical spine to the affected side. After a few seconds, the patient complains of vertigo, caused by a compression of the vertebral artery of this side (the *lower side*)

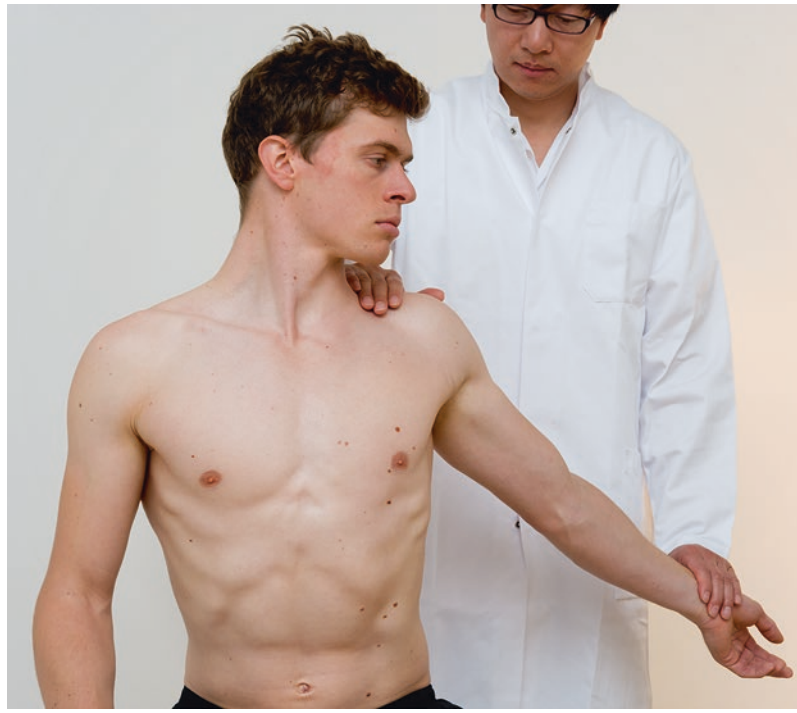


Fig. 1.13 Adson test: The patient turns his head to the painful side while inhaling deeply. The examiner moves the arm of the same side backward and downward. The test is positive if the pain increases, if sensory disorder occurs, if the radial pulse weakens, or if stenosis sounds can be heard over the subclavian artery

1.2.2 Leading Symptoms of the Cervical Spine

The leading symptoms of the cervical spine are summarized in Table 1.1.

1.2.3 Disorders of the Cervical Spine

- **Clinical presentations of disorders**

Wry Neck (Torticollis)

Fixed misalignment of the head of a neonate or infant. The head is tilted to the diseased side and rotated to the healthy side.

- *Etiology:* Due to intrauterine positions or birth trauma, a connective tissue shortening of the sternocleidomastoid muscle occurs. Genetic factors are being discussed.
- *Patient history:* Movement impairment and malpositioning of the head.
- *Examination:* Tilting of the head to the diseased side and rotation toward the healthy side. Occasionally swelling of the sternal muscle insertion. Hardening and shortening of the diseased muscle. Eventually facial scoliosis develops.
- *Diagnostics:* Cervical X-ray in two levels to exclude a bony torticollis or a basilar invagination.
- *DD:* M. Klippel-Feil, basilar invagination, ocular torticollis.

Acute and Chronic Cervical Spine Syndrome

This syndrome describes pain in the region of the cervical spine. If the pain radiates toward the arms, it is called cervicobrachial syndrome; if it radiates toward the back of the head, it is called cervicocranial syndrome. One differentiates between chronic and acute cervical syndrome.

In cervicobrachial syndrome, the segments C4 to C7 are affected. In cervicocranial syndrome, the segments C0 to C3 are affected. The vertebral artery and the sympathetic nerves can also be affected.

- *Etiology:* Acute and chronic blocks in the small intervertebral joints as well as wear found in most degenerative diseases can be seen as the cause. Acute pain can set in after whiplash injury or after longer incorrect load bearing as well as exposure to cold draughts. Further

Table 1.1 Leading symptoms of the cervical spine

History	Pain	Local findings, functional tests	Sensory function disorder	Motor function disorder	Points to:
Incorrect load bearing, slight distortion, acute pain	Local neck pain	Painful limitation of the range of motion, localized tenderness to pressure	Normally none	Normally none	Acute cervical spine syndrome
Chronic strain (computer work, secretary), chronic pain	Neck pain	Painful at the end of the movement, limited range of motion, paravertebral tenderness	Normally none	Normally none	Chronic cervical spine syndrome
Chronic strain (computer work, secretary), headache, vertigo, chronic pain	Cervical and occipital radiating pain	At the end of the movement painfully limited mobility, nystagmus, suboccipital tenderness	Normally none	Normally none	Cervicocranial syndrome
Chronic strain (computer work, secretary), chronic pain	Radiating pain in the shoulder, neck, and arm, not assignable to a specific segment	At the end of the movement painfully limited mobility, esp. the rotation at max. reclination, tenderness to pressure at the lower cervical spine, myogeloses	Normally none, dysesthesia not segmental	None	Cervicobrachial syndrome
Nocturnal pain or post-strain pain	Radiating shoulder and neck pain, ulnar forearm, lateral edge of the hand, 4th and 5th fingers	Adson's sign is positive (turning the head to the affected side)	Hypesthesia ulnar forearm, lateral edge of the hand, 4th and 5th fingers	Later failure of small hand muscles with atrophy and paresis	Scalenus syndrome DD: costoclavicular syndrome
Pain, especially at night and after exercise	Radiating shoulder and neck pain, ulnar forearm, lateral edge of the hand, 4th and 5th fingers	Positive modified Adson test (turning the head to the healthy side)	Hypesthesia ulnar forearm, lateral edge of the hand, (4th and 5th fingers)	None	Cervical rib

Table 1.1 (continued)

History	Pain	Local findings, functional tests	Sensory function disorder	Motor function disorder	Points to:
Acute, usually chronic pain, asthenia and sensory disturbances	Radiating pain in the shoulder, neck, and arm, to assign segmental, coughing, sneezing, and pressing pain	Positive cervical compression test, limited mobility, reflex deficit: biceps reflex (C5), brachioradialis reflex (C6), triceps reflex (C7)	Paresthesia possible, segmentally assignable: M. deltoideus (C5), the radial arm (C6), finger 2–4 (C7), little finger (C8)	Paresis possible: shoulder abduction (C5), flexion elbow (C6), extension elbow (C7), flexion hand (C7), adduction and abduction of the fingers (C8)	Radicular cervical compression syndrome (rare!)
Unbalanced one-sided stress, slowly progressive weakness in the arms and/or legs, unsteady gait	Diffuse, partly radicular pain	Restricted mobility, increased reflexes	Uncharacteristic (also radicular or similar paraplegia!), paresthesia in hands and feet	Possibly voiding disorders, paresis (symmetrical, asymmetrical) tetra- or paraspasticity, flaccid paralysis of the hand (so-called myelopathic hand)	Chronic vertebral cervical myelopathy
Intrauterine predicament, birth trauma	Mild pain	Head inclined to the healthy side, rotated to the diseased side	None	None	Muscular torticollis
Childhood, combined with other malformations, deafness (rare)	Only in old age, radiating pain into the back of the head and arms	Short neck, low hairline, restricted mobility, elevated scapulae	None	Facial palsy (rare)	Klippel–Feil syndrome
Juvenile rheumatoid arthritis, long-lasting rheumatoid arthritis, sensation of stiffness	No pain or resting and exercise pain, radiated to the mandible and occiput; radicular pain	Unsteadiness, rotation in anteflexion limited pain	Paresthesias in hands and feet	Weakness of the upper extremities, flaccid paralysis of the hands (myelopathic hand)	Atlanto-occipital instability
Resistant to any therapy (suspected) cervicobrachial, Tietze, or impingement syndrome	Local pain in the anterior chest wall radiating into the arm	Tense shoulder and neck muscles, restricted mobility, Horner's triad	Dysesthesia possible	None	Pancoast tumor

causes are infections (rheumatoid arthritis) and tumors (rare). The etiology of cervicocranial syndrome is diverse. An interdisciplinary investigation including neurology, ENT, and internal medicine is always required.

- *Patient history:* Acute (days, weeks) or chronic neck pain that originates from the cervical spine. If chronic, the pain often radiates into the arms (cervicobrachial syndrome). In this case, patients complain of dysesthesia. Pain that radiates into the back of the head (cervicocranial syndrome) is often accompanied by rotating vertigo and painful impairment of cervical movement.
- *Examination:* Paravertebral tenderness on the affected segments, suboccipital and/or at the upper margins of the trapezoid muscle. In part increased muscle tone in the paravertebral muscles and myogelosis. Deviations from the perpendicular (Fig. 1.1). Movement impairments (rotation and sideways tilt) often unilateral (Figs. 1.2, 1.3, and 1.4). In the case of simple blocks, the traction test brings relief (Fig. 1.6). After whiplash injury, the cervical spinal can be tender when compressed (Fig. 1.5). Pain that radiates into the arm, as well as dysesthesia, can often not be pinpointed to certain segments. When the upper segments are involved, a gaze-evoked nystagmus can often be seen. The deep tendon reflexes are normal.
- *Diagnostics:* X-ray of the cervical spine in two planes and in the semi-oblique projection for degenerative changes.
- *DD cervicocranial syndrome*: Vertebral artery syndrome, de Kleijn (Fig. 1.12) positive—patient lies prone on the examination table. Passive retroflexion, tilt, and rotation of the cervical spine to the affected side. After a few seconds, patient complains of vertigo, caused by a compression of the vertebral artery of this side.

- **Neurological conditions**

Radicular Compression Syndrome in the Cervical Spine

Cervical spinal root compression syndromes are characterized by radiating shoulder and neck pain that can be traced back to certain segments and are often accompanied by paresthesia. Radicular compression is less common in the cervical spine compared to the lumbar spine.

- *Etiology:* Compression of a nerve root due to degenerative enlargement of the uncinate process or due to disc herniation or protrusion.
- *Patient history:* Acute (rare) or chronic (more frequent) shoulder and neck pain. Pain that radiates up to the arms. Sometimes paresthesia. Pain upon coughing, sneezing, and pressing.
- *Examination:* (Acute) Wry neck. Gaze-evoked nystagmus (upper segments). Suboccipital and paravertebral tenderness. Positive compression test (Fig. 1.5). Movement impairment of the cervical spine. Sensory loss and paresis. Absent reflexes or side difference.

Increased deep tendon reflexes, spastic muscle tone, and urinary incontinence (paraplegia symptoms) are highly suspicious of spinal disc herniation.

- *Somatosensory loss* (Fig. 1.11) that can be traced back to a certain dermatome is a sign of damage to the specific root. The region of the deltoid muscle is supplied by C5; the outer part of the upper limb and the radial part of the lower limb including the thumb are supplied by C6. Lateral and dorsal to C6 and the fingers II–IV are supplied by C7. The ulnar hand and the little finger are supplied by C8.
- *Motor loss* of the C5 root is expressed in weakness in shoulder abduction and elbow flexion. Damage to C6 leads to an isolated paresis of flexion elbow. Weakness in the flexion of the hand and extension of the elbow occurs when C7 is damaged. A weakness in the abduction; adduction is connected to C8 damage.
- Absent or depressed reflexes can be a neurological sign of root damage.
- The biceps reflex (Fig. 1.8) communicates with the C5 root, the brachioradialis reflex with (Fig. 1.9) C6, and the triceps reflex with (Fig. 1.10) C7 und C8.
- *Diagnostics:* X-ray of the cervical spine in two planes and semi-oblique to rule out bony alterations. CT and MRI to prove disc herniation or protrusion. Neurological consultation including possible EMG.
- *DD:* Neuralgic shoulder amyotrophy, carpal tunnel syndrome, compression of the ulnar nerve.

Chronic Cervical Myelopathy Deriving from the Vertebra

This disease describes a mostly unilateral, slowly progressive weakness of the arms and/or the legs caused

by a stenosis of the spinal canal at one or more levels. The levels C4–C7 are frequently affected.

- *Etiology:* Mostly due to osteophytes (cervical spondylosis). Cervical myelopathy can also occur in rheumatic disease involving atlantooccipital instability.
- *History:* Often chronic neck pain. Weakness and a sensation of heaviness in the arms and/or the legs, often unilateral. Gait instability, diffuse, but also radicular pain in the arms and legs. Bladder or urinary problems are rare.
- *Examination:* Reduced mobility of the cervical spine (Figs. 1.2, 1.3, and 1.4). Sensory loss is not characteristic (mostly absent, but can also present similar to losses seen in radicular or spinal trauma). Motor loss in the form of paresis (symmetrical or unilateral) or spastic tetra- or paraplegia. Deep tendon reflexes (Figs. 1.41 and 1.42) are increased; the Babinski sign is positive (Fig. 1.43), possibly also the Gordon and Oppenheimer signs (Figs. 1.44 and 1.45). The "myelopathic hand" could also possibly be seen: thenar, hypothenar, and interosseous muscle atrophy.
- *Diagnostics:* X-ray of the cervical spine in two planes and semi-oblique. CT and MRI to visualize bony stenosis and to exclude disc herniation or protrusion. Neurological consultation (EMG).

Lesions of the Cervicobrachial Plexus, C1–T1 (T2)

Divided into lesions of the cervical plexus and lesions of the brachial plexus. The brachial plexus is further divided in the upper, the whole, and the lower plexus lesions.

- *Diagnostics:* As with all plexus lesions, neurological examination and EMG is required. This serves to verify the damage and the extent of the lesions. Furthermore, myelography (bloody cerebrospinal fluid or an "empty root pouch" as a sign of root lesion).

Especially in the case of traumatic damage, the clinical presentation can initially be inhomogeneous. This calls for a repeat of the clinical examination.

- Sweat secretion upon pilocarpine or a histamine test (local flush reaction). For this one must consider that the sympathetic nerves originate below T3. If the vegetative innervation of the upper extremity is intact (sweat secretion, localized flushing), root damage is almost certain. Plexus lesions can, however, also be combined with root damage.

Lesions of the cervical plexus (C1–C4)

Relatively rare, because the plexus is anatomically well secured. Patients rarely survive trauma in this region. Tumors, inflammation, and radiation damage rarely present in this region.

Brachial plexus lesions ((C4) C5–Th1 (Th2))

Lesions of the root or the plexus.

- *Etiology:* Direct trauma (e.g., motorcycle accidents); iatrogenic (perioperatively due to patient positioning in anesthetics, brachial plexus block), birth trauma, inflammation, radiation damage, compression syndrome, neuralgic shoulder amyotrophy.

Upper brachial plexus lesion (Duchenne–Erb)

Most common monoplegia. Affects C5/C6.

- *Etiology:* Mostly caused by trauma, including birth trauma.
- *History:* Patients are unable to use the shoulder to lift the arm away from the trunk. The arm hangs flaccid and the hand is rotated inward.
- *Examination:* Shoulder, active abduction and outer rotation M0; elbow, active flexion and supination M0. Hypesthesia (Fig. 1.11) over the deltoid muscle and the radial side of the lower arm.

Whole lesion of the upper brachial plexus

Paralysis similar to Duchenne–Erb. Yet includes, beyond C5–C6, also C7. (The singular lesion of C7 is also referred to as mid-arm plexus lesion. C7 lesions can also occur in combination with lower brachial plexus lesions.)

- *History:* Arm lift impossible. Arm hangs flaccid and rotated inwardly. Weakness in the arm and hand.
- *Examination:* Shoulder, active abduction and outer rotation M0; elbow, active extension/flexion as well as pronation reduced. Hypesthesia (Fig. 1.11) over the deltoid muscle and the radial side of the lower arm and the hand.

Lower brachial plexus lesion (type Déjerine–Klumpke)

Relatively rare. Paralysis of C8 and T1. Includes paralysis of the lumbrical muscles, the long finger flexors, and in part the long hand flexors.

- *History:* Drastic functional impairment of the hand.

- *Examination:* Paresis of the small hand muscles (e.g., lumbrical muscles) and the long finger flexors. Ulnar claw (Fig. 2.46). Sensory loss on the ulnar side of the lower arm and hand is always present under cervical impingement syndrome (Fig. 1.11). Often accompanied by Horner's syndrome (Fig. 1.7).

Impingement Syndromes

Chronic damage to the lower parts of the brachial plexus. Can be accompanied by stenosis of the local blood vessels.

- *Etiology:* Compression at anatomically narrow areas.
- *Examination:* Provocation test (Adson test); not very specific, also positive in healthy persons. X-ray of the cervical spine in two planes and of the shoulder in two planes. Neurological consultation (EMG, nerve conduction velocity (NCV)). Doppler sonography, angiography (DSA).
- *DD:* Pancoast tumor (pain-free); neuralgic shoulder amyotrophy; "backpack palsy" (Fig. 1.24)(due to carrying a heavy load on the shoulders); less common is thrombosis in the axillar vein, occlusion of the brachial artery.

Cervical rib

Additional rib at C7

- *Etiology:* Congenital.
- *History:* Shoulder and neck pain especially at night and upon exertion. Numbness and pain can be found in the ulnar lower arm, the lateral hand, and the fourth and fifth digit.
- *Examination:* Pain can be provoked by turning the head to the healthy side. This causes loss or weakening of the radial artery pulse and hypesthesia in the fourth and fifth digit (Fig. 1.11).

Scalenus syndrome

Impingement of the subclavian artery and the brachial plexus in the course of their exit through the frontal scalene hiatus. Can lead to motor function loss in the small hand muscles, including atrophy and paresis.

- *Etiology:* Enlarging of the anterior scalene muscle at its insertion sight.
- *History:* Brachialgia, paresthesia, sensory loss. In the course of disease, weakness of the hand.
- *Examination:* Positive Adson test (Fig. 1.13). This test involves turning and lifting the head toward the affected side while the patient simultaneously inhales deeply and the ipsilateral arm is pulled in a caudal direction. Sensory loss in the fourth and fifth digit and the lateral hand. Finger abduction and adduction are limited.

Costoclavicular syndrome

Compression of the brachial plexus, the subclavian artery, and the subclavian vein between the clavicle and the first rib.

- *Etiology:* Partly congenital, improper healing of clavicle fractures (fibrocartilage callus), tumors in the clavicle.
- *History:* Brachialgia, paresthesia, sensory loss.
- *Examination:* Positive Adson test (Fig. 1.13). This test involves turning and lifting the head toward the affected side while the patient simultaneously inhales deeply and the ipsilateral arm is abducted up to the horizontal plane and pulled backward. Sensory loss in the fourth and fifth finger and the lateral hand.

Hyperabduction syndrome

Rare. Compression of the blood vessels and nerves between the coracoid process and the minor pectoralis minor muscle.

- *Etiology:* Regular hyperabduction of the arm, often in a context of work or sport (builders, painters, javelin).
- *History:* Brachialgia, especially during the abovementioned actions, also during sleep with a cranially extended arm.
- *Examination:* Pain provocation by passive retroversion of the arm in maximum elevation. Weakening of the radial pulse. Motor or sensory loss rare.

- **Congenital malformation**

Klippel–Feil Syndrome

Congenital fusion of two or more cervical vertebrae. Often associated with other dysplasia, especially in the upper limb (syndactyly, hypoplasia, Sprengel anomaly) but also of the internal organs (kidney, heart).

- *Etiology:* Unknown.
- *History:* Localized or radiating pain the arms and the back of the head. This can often occur in old age due to premature wear of the vertebrae. Often reduced range of motion in the cervical spine.
- *Examination:* A short neck and low hairline is often seen. Scoliosis is common as well as in combination with the Sprengel anomaly

(elevated shoulder blade). Sometimes the dysplasia of the cervical spine causes a bony wry neck. Facial nerve palsy or deafness is rare.
- *Diagnostics:* X-ray of the cervical spine in two planes and semi-oblique. Eventually functional imaging. Neurological consultation (EMG, NCV) and internal medicine consultation (dysplasia of the internal organs).
- *DD:* Muscular and ocular wry neck. Synostosis of the spine in the context of juvenile polyarthritis and Bechterew disease.

- **Degenerative Disorders**

Uncovertebral Joint Arthrosis

Degenerative enlargement of the uncinate process. Can lead to constriction of the intervertebral foramina.
- Clinically presents itself as cervical, cervicocranial, and cervicobrachial syndrome. Also present in radicular cervical compression syndrome in chronic myelopathy of cervical vertebrae.
- *Diagnostics:* X-ray of the cervical spine in two planes and semi-oblique to reveal stenosis of the intervertebral foramina.

Spondylosis

Bony protrusions on the vertebral margins.
- Can occur in all clinical presentations with a degenerative character. In severe cases, it can affect several levels, e.g., cervical spondylotic myelopathy.
- *Diagnostics:* X-ray in two planes, semi-oblique.

Intervertebral Osteochondrosis

Degenerative alterations of the base and upper plates of the vertebra. This condition is accompanied by ventral and/or dorsal spondylophytes. Occurs isolated but also in combination with all other degenerative diseases.
- Can occur in all clinical disease presentations of degenerative character.
- *Diagnostics:* X-ray of the cervical spine in two planes.

Disc Protrusion/Herniation

Rare in the cervical spine. Protrusion or herniation of the intervertebral disc into the spinal canal. The condition is often accompanied by other degenerative alterations of the vertebral base and upper plates and the intervertebral joints. The clinical presentation is commonly acute rather than chronic.
- Mostly clinically silent intraforaminal and dorsolateral herniations. These can present as a cervical, cervicocranial, and cervicobrachial syndrome. In rare cases, herniations can present as cervical radiculopathy.
- *Diagnostics:* X-ray of the cervical spine in two planes and semi-oblique. MRI and CT in case of motor function or sensory function loss.

Spinal Stenosis

Constriction of the spinal canal in a context of degenerative alterations of the cervical spine (mostly dorsal spondylophytes in intervertebral osteochondrosis).
- Clinically emulates chronic myelopathy of the cervical vertebrae.
- *Diagnostics:* X-ray of the cervical spine in two planes and semi-oblique. MRI and CT in case of motor or sensory loss. Neurological consultation (EMG).

- **Inflammatory disorders**

Nonspecific and Specific Inflammation: Spondylitis, Spondylodiscitis

Rare in the cervical spine. Nonspecific bacterial or aseptic inflammation of the intervertebral disc affecting the neighboring vertebra (spondylodiscitis) or osteomyelitis of the vertebra (spondylitis).
- *Diagnostics:* X-ray of the cervical spine in two planes and semi-oblique. MRI and CT to show localization and extent of the inflammation. Scintigraphy to determine the activity of inflammation.

Rheumatic Disease

Spondyloarthritis

Degenerative inflammatory alterations to the smaller intervertebral joints in the context of rheumatic disease. Significance has decreased due to the systemic nature of the disease.

Atlanto-occipital instability

Instability of the upper cervical spine as a consequence of ligament and joint destruction by a chronic inflammatory process. An atlantoaxial subluxation and a cervical dens luxation (pseudobasilar invagination of the dens). Subaxial spondylolisthesis. Dens destruction can also occur.

- *Etiology:* Juvenile chronic polyarthritis and after chronic rheumatoid arthritis.
- *History:* Pain at rest and movement dependent, partly radiating into the mandible and the back of the head. Hypesthesia and paresthesia at the back of the head are possible.
- Radicular pain and pain during anteversion of the head. Signs of cervical myelopathy or vertebrobasilar insufficiency can occur. The rheumatic disease is in the foreground.
- *Examination:* Typical examination findings of rheumatoid arthritis. Rotation during anteflexion is limited (cracking sound). Clinical signs of chronic cervical myelopathy can also be present.

The clinical examination must be completed very carefully in order to prevent iatrogenic injury.

- *Diagnostics:* X-ray of the cervical spine in two planes. Functional radiography in extension and flexion.

- **Traumatic disorders**

Traumatic disorders of the cervical spine include soft tissue injury, subluxation, dislocation, and fractures with or without medullar involvement.

Soft Tissue Injury and Fractures

Soft tissue injury in the cervical spine forms the most common cervical spine injury. Strain on the soft tissue is called distortion. The mechanism of injury needs to be established thoroughly, also in patients where the injury is in the less recent past. The various patterns of injury are well described in the literature.

Diagnostics of cervical spine fractures depends largely on the patient history and on X-ray imaging. One differentiates between injuries of the dens, the atlas, and the lower cervical spine. The latter includes fractures of the vertebra (compression and burst fracture), rupture of the posterior ligaments, unilateral or bilateral facet luxation, dislocation fracture, and stress fracture of the spinous process (clay shoveler fracture). One distinguishes stable and unstable fracture.

Important fractures include the Jefferson fracture (Atlas fracture), the Hangman's fracture (fracture of the axis), the dens fracture, and the teardrop contusion (avulsion of the anterior or posterior margin of the vertebra). This book will not aim at a precise description of these fractures.

- *Etiology:* Axial compression of the head onto the neck, e.g., acceleration injury, polytrauma.
- During the first orienting clinical examination, the examiner might find malpositioning of the head and axial deviation of the spine. Tenderness can also be present. If fracture is likely, movement examination should not be performed until fracture can be ruled out. Various forms of sensory and motor loss can be present.

Essential for the diagnosis of cervical spine fractures is a complete neurological examination (as well as documentation) and X-ray imaging.

- **Tumors affecting the cervical spine**

Pancoast Tumor

Special form of peripheral lung cancer located apically in the lung and known for an early infiltration of the thorax.

- *History:* Pain that radiates into the arm (cervicobrachial syndrome) as well as Tietze syndrome can be the first signs (**see page 43 there**). Swelling is possible.
- *Examination:* Increased muscle tone in the shoulder and neck muscles. Paravertebral tenderness with reduced rotation (Fig. 1.4) and leaning (Fig. 1.3). If the C8 or D1 roots are irritated, Horner's syndrome—ptosis, miosis, and enophthalmus—is fairly typical (Fig. 1.7). Dysesthesia is possible; no motor function losses (but radiculopathies of C8 are known to occur (Fig. 1.11)).
- *Diagnostics:* X-ray of the cervical spine in two planes and semi-oblique. X-ray of the thorax. In some cases, MRI or CT scans to visualize the tumor and the extent of its spreading.

1.3 Thoracic and Lumbar Spine

1.3.1 Systematic Examination

- **Findings**

Gait	Normal, right/left, limping	Pain-induced limping, shortening-induced limping, protective limping, stiffness-induced limping
Perpendicular line from (C7 to S1)	Steep/overhang	Right/left
Kyphosis (thoracic spine)	Standing/rolled-up position on the floor	Normal/flattened/increased/gibbus (actively erectable/fixed)
Lordosis (LWS)	Normal/flattened/increased	"Christmas-tree phenomenon"—downward diagonal skin lines at the back
Scoliosis	None; if present then:	Right/left convex Rib hump (right/left) Lumbar (right/left) Lower back triangles (uniform/elapsed/left/right) Fixed/active erectable (complete/incomplete)
Sternum	Pectus carinatum/pectus excavatum	Yes/no
Scapula	Normal/protraction/scapula alata	Right/left
Shoulder position	Shoulders at equal height/shoulder elevation	Right/left
Pelvic position	Pelvic obliquity expressing compensation for leg shortening	Right/left (–cm)
Level over the spinal process	None; if present then:	Level of the spine
Swelling/redness/hyperthermia	None; if so:	Localization/extent/size/consistency (soft/firm/movable)
Hematoma/abrasion/open wound/scab	None; if present then:	Localization/extent/size
Scarring	None; if present then:	Localization/expansion/consistency (soft/firm/movable)
Musculature	Paravertebral muscles, pectoral muscles (thoracic spine) Abdominal muscles (lumbar spine)	Highly developed/wasted/shortened/atrophy (significant?), myogeloses (soft/tense)
Matthias test	Postural weakness	Negative/positive
Respiratory width (height T9)	Chest circumference at height Th 10 in inspiration/at expiration	--cm/- cm (difference --cm)
Mobility	Fingertip-to-floor distance	--cm

	Schober	––/––cm
	Ott	––/––cm
	Reclination	-- degree
	Sideward tilt	––/––/–– degrees (to the right above L-, to the left above L-)
	Rotation (sitting)	––/––/–– degree
Motion pain	None; if present:	Direction, continuous/at the end
Tenderness to pressure	None; if present then:	Spinous/interspinous/paravertebral (level; right/left)
		Iliac crests (localization)
		Sacroiliac joint (right/left)
Tenderness to knocking	None; if present:	Spinous/interspinous (level)
Chest compression pain	None/positive	
Heel drop pain	None/positive	
Pseudo-Laségue	Negative/positive	
Sacroiliac joints	Tenderness	Negative/positive (right/left)
	Patrick's test	Negative/positive (right/left)
	Mennel	Negative/positive (right/left)

- **Neurology**

Pain induced placing nerves under traction	Laségue	Negative/positive (right/left) at -- degrees
	Crossed Laségue	Negative/positive (right/left)
	Bragard	Negative/positive (right/left)
	Pain originating from femoral nerve	Negative/positive (right/left)
	Valeix	Negative/positive (right/left)
Reflexes	Patellar tendon (L4) Tibialis posterior (L5) Achilles tendon (S1)	Right/left Vigorous/decreased/absent/supernormal (hyperreflexic)
	Abdominal reflexes	Negative/positive (right/left)
	Babinski Gordon Oppenheimer	Negative/positive (right/left) Negative/positive (right/left) Negative/positive (right/left)
Sensitivity	Dermatome (segmentally assignable/not exactly assignable)	Hypesthesia/paresthesia/dysesthesia (right/left) Saddle anesthesia
Motor activity	Knee flexion/adduction (L3) Knee extension/hip abduction (L4) Heel stance (dorsiflexors, L5) Toe stance (plantar flexors, S1)	Intact/attenuated (M0–M1–M2–M3–M4–M5) (right/left)
	Anal sphincter tone	Tight/normal/no discernable tone

- **Circulation**

Arteries	A. femoralis A. popliteal A. dorsalis pedis A. tibialis posterior	Fully/barely/not palpable (right/left)
Venen *Veins*	Varicosis cruris Venous stasis Hyperpigmentation	Absent/present (right/left) Absent/present (right/left) Absent/present (right/left)
Capillary pulse	Tip of the toes	Visible/invisible

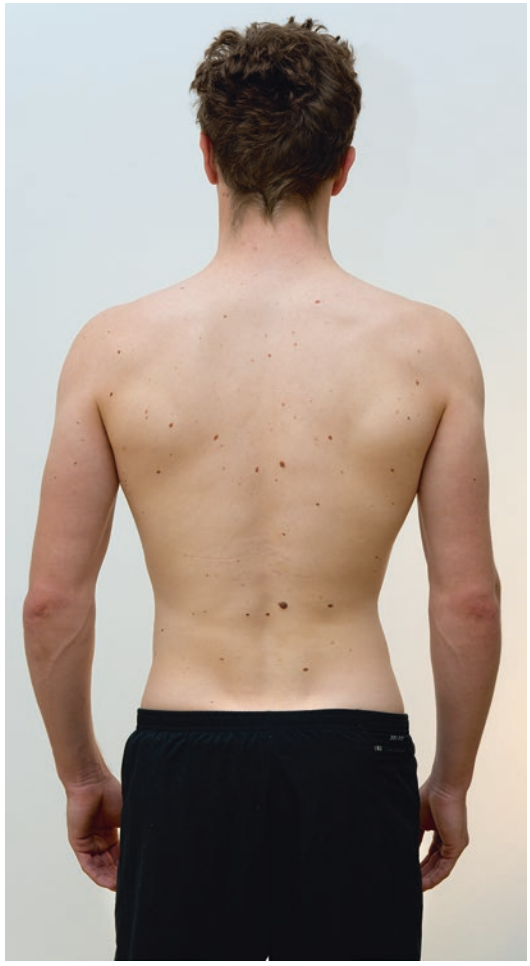


Fig. 1.14 The spine is considered from an imaginary perpendicular line. The examiner inspects the paravertebral muscles. This figure illustrates a steepened position of the spine

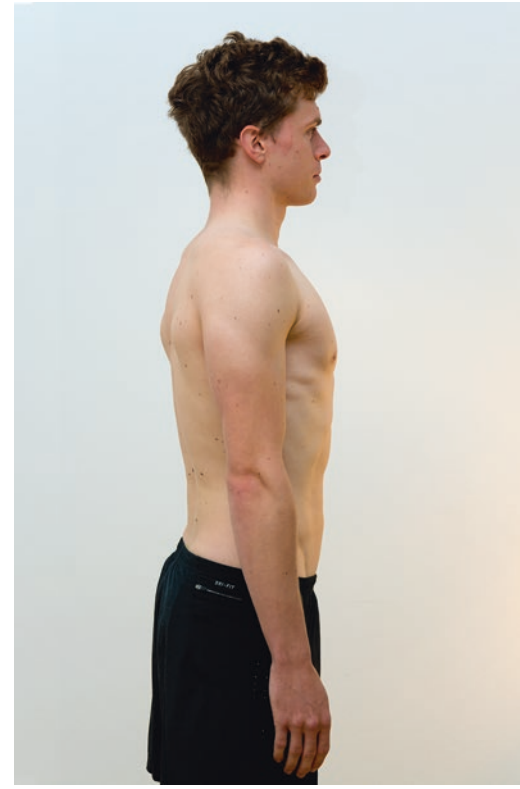


Fig. 1.15 Normal kyphosis of the thoracic spine and lordosis of the lumbar spine

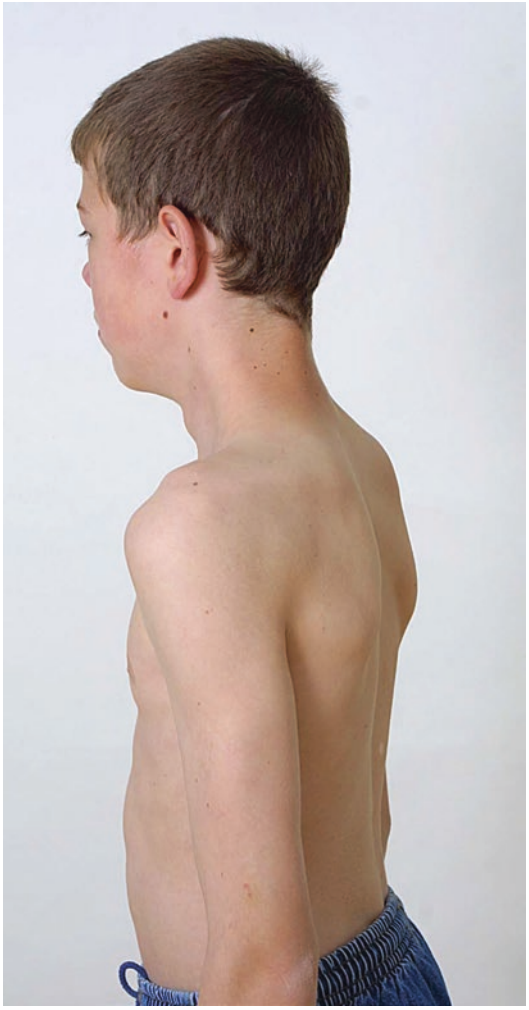


Fig. 1.16 Flattened kyphosis of the thoracic spine and lordosis of the lumbar spine

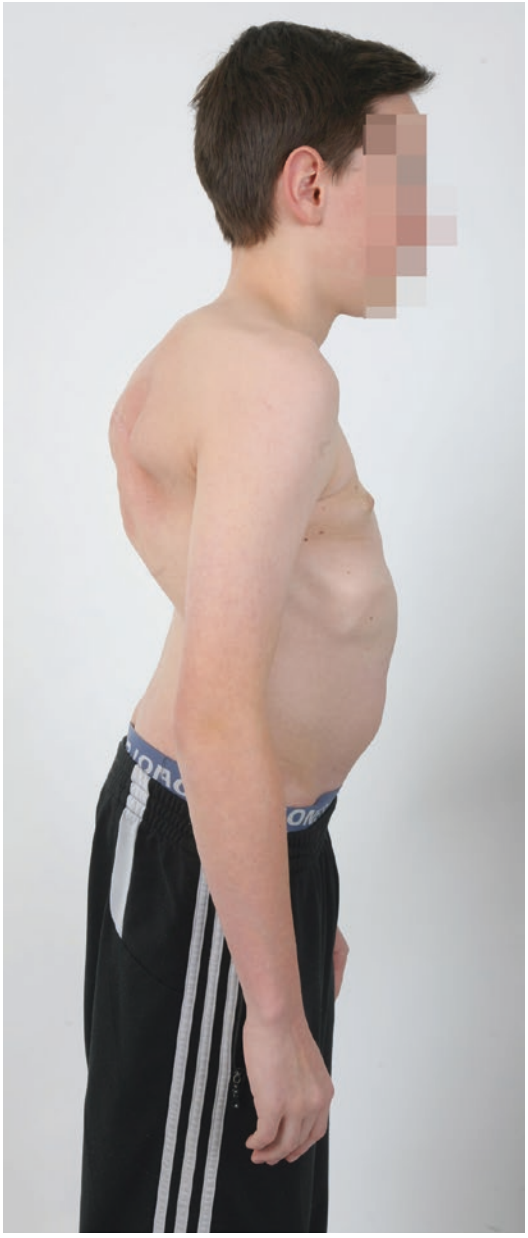


Fig. 1.17 Increased kyphosis of the thoracic spine and lordosis of the lumbar spine (in this case kyphosis of the adolescent). Less severe findings can be considered normal posture variations

Fig. 1.18 When the patient, on all fours, moves from making his/her body into a tight ball (**a**) to slowly moving forward with his/her arms on the examination table or floor (**b**), the segmental kyphosis or the decreased lordosis becomes visible testing the thoracic spine kyphosis

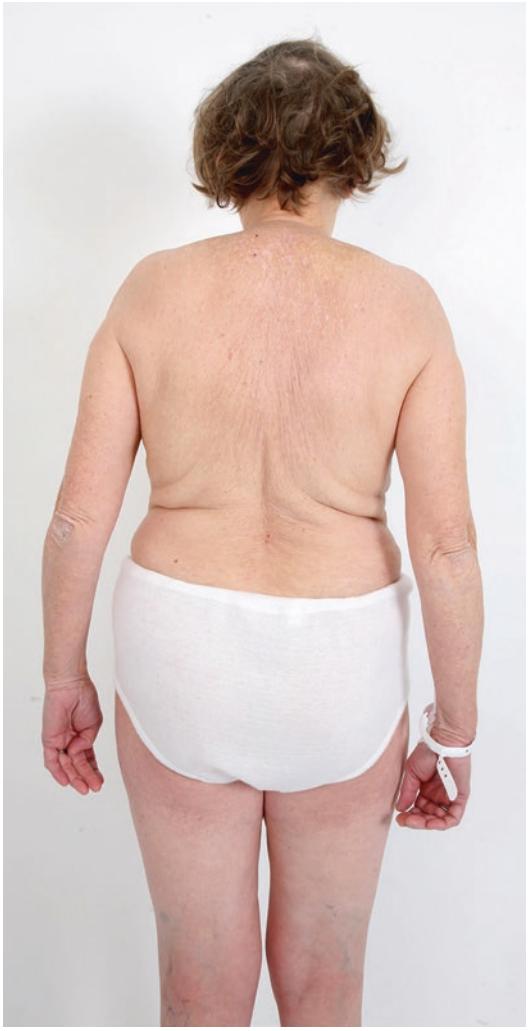


Fig. 1.19 "Christmas-tree phenomenon." Due to osteoporotic sintering of the spine, the lower ribs move downward toward the pelvis. This creates downward-pointing diagonal folds in the skin that resembles a Christmas tree

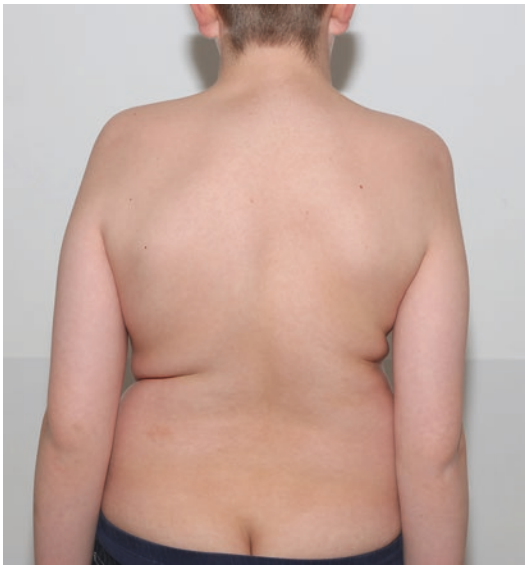


Fig. 1.20 S-shaped structural scoliosis, convex to the left in the thoracic spine, convex to the right in the lumbar spine. Elevated shoulder on the *left side* and absent *lower back* triangles (Image courtesy of Prof. E. Heyde, University of Leipzig)

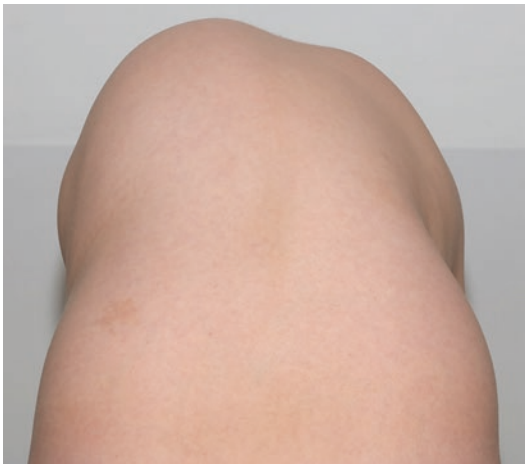


Fig. 1.21 Hump in the ribs seen on the left and lumbar bulge on the *right* in a patient with structural scoliosis (Image courtesy of Prof. E. Heyde, University of Leipzig)

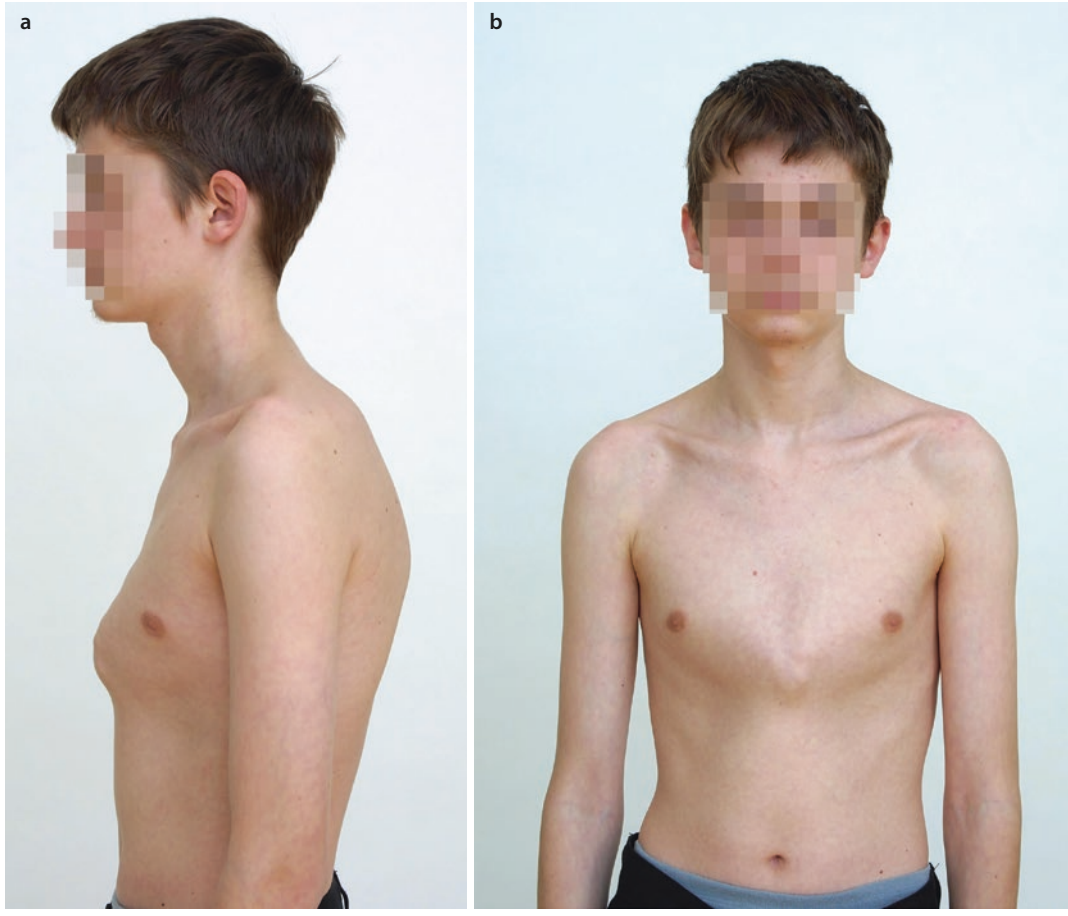


Fig. 1.22 (**a**, **b**) Pectus carinatum from the side (**a**) and the front (**b**)

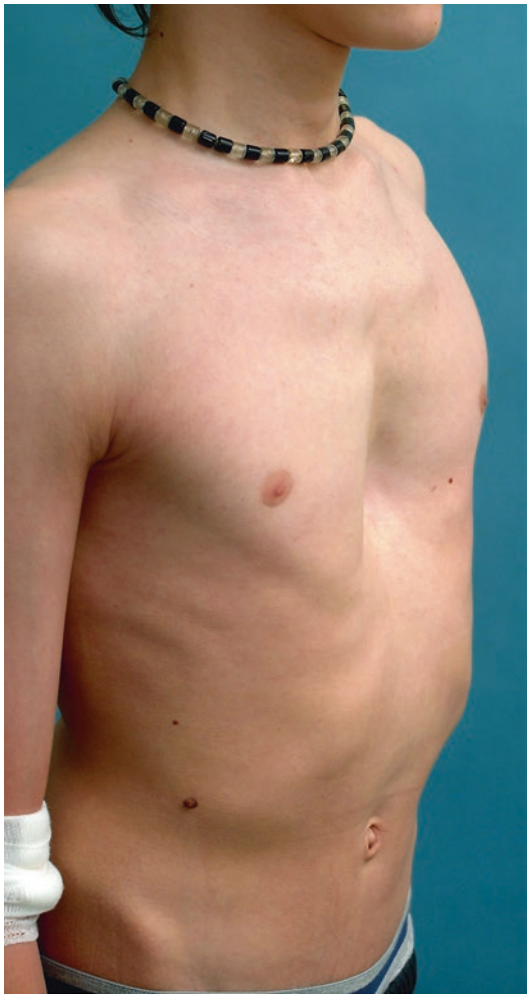


Fig. 1.23 Pectus excavatum

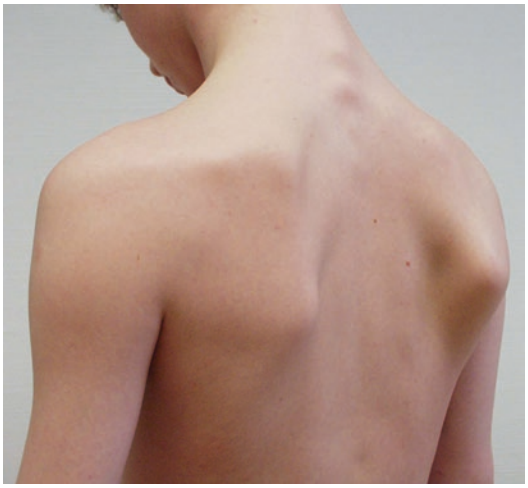


Fig. 1.24 Scapula alata "winged scapula" on the right. The deviation becomes clearer when the patient is asked to raise both arms in front of the body and to press against a wall

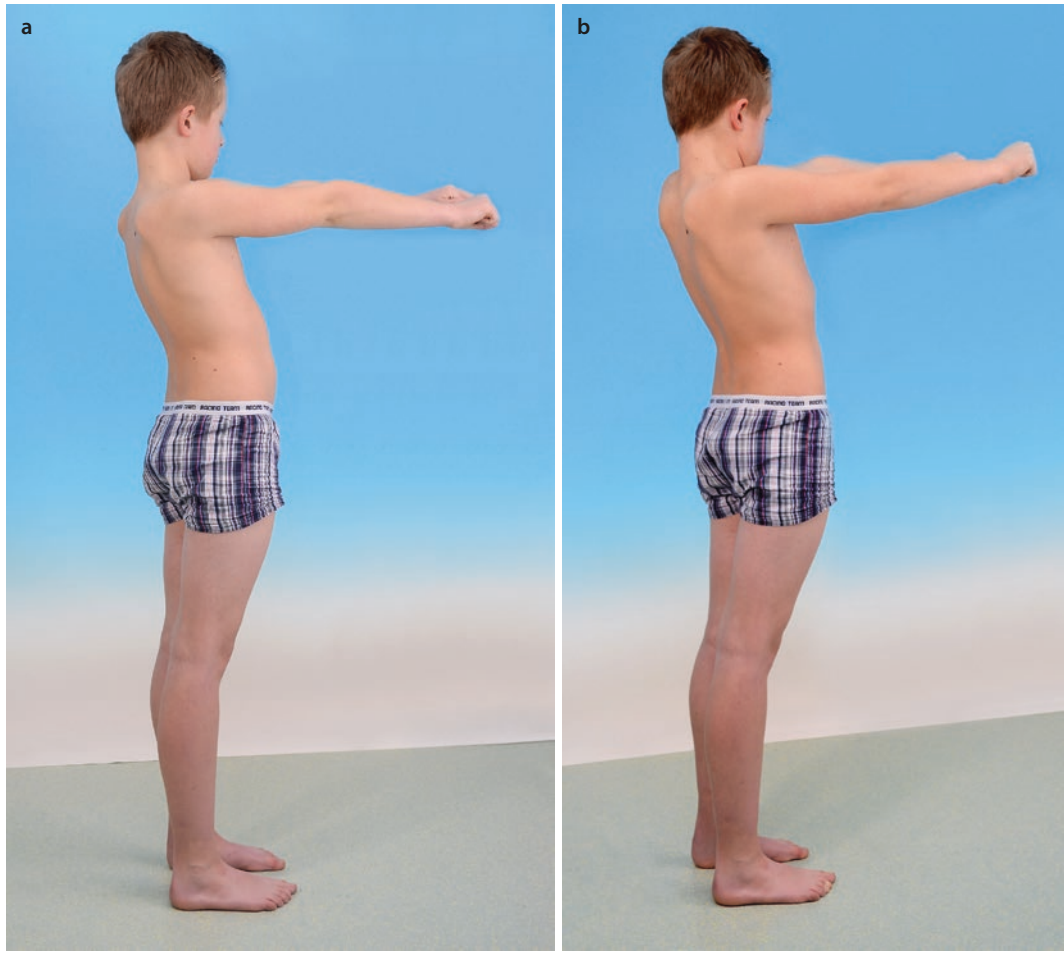


Fig. 1.25 (**a**, **b**) Matthias test (in children): the arms should be stretched forward while the patient stands upright. In case of muscular insufficiency of the trunk, the upper body falls backward after 30 s in order to keep the arms up (**b**). The lumbar lordosis is increased (postural weakness). If the upright stance cannot be performed with stretched-out arms, then postural collapse is likely (Images courtesy of Dr. André Sachse, Orthopedics University of Jena/Eisenberg)

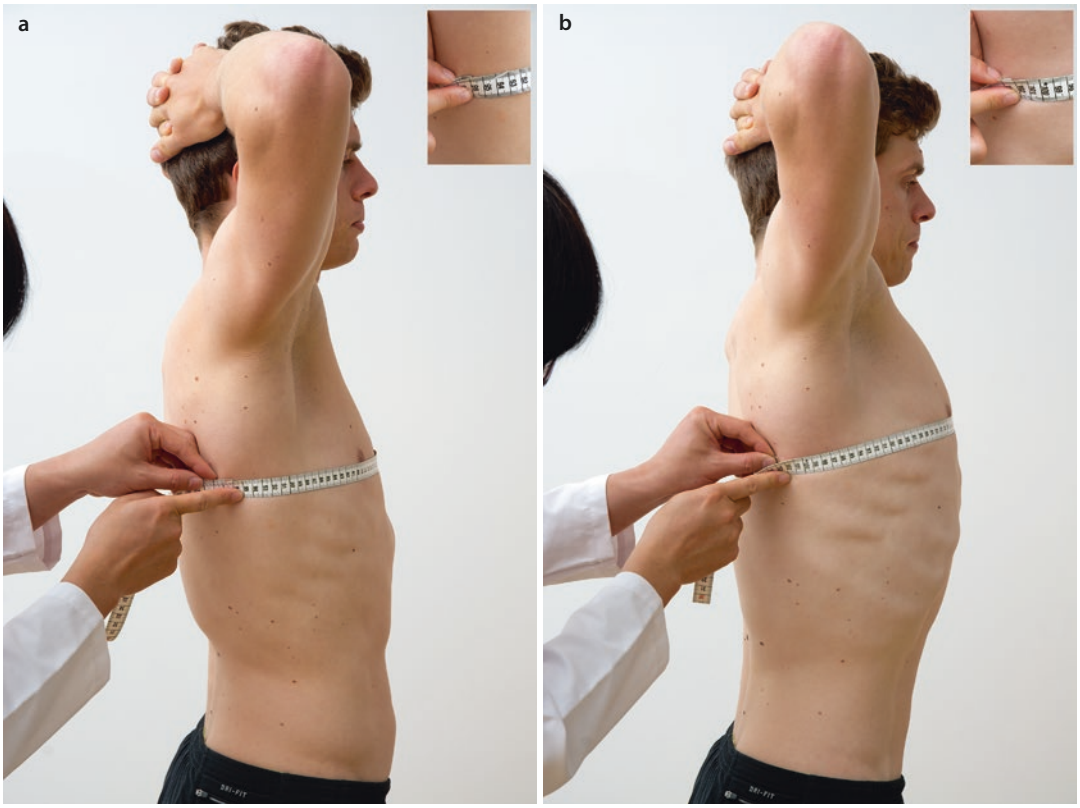


Fig. 1.26 (**a**, **b**) Chest expansion when breathing: the circumference of the thorax is measured at T4–5 during inspiration (**a**) and during expiration (**b**). The difference in circumference is recorded in cm

Fig. 1.27 Measuring the finger-to-floor distance: the distance between the finger tips and the floor during maximal anteflexion of the trunk (normal values 0–20 cm)

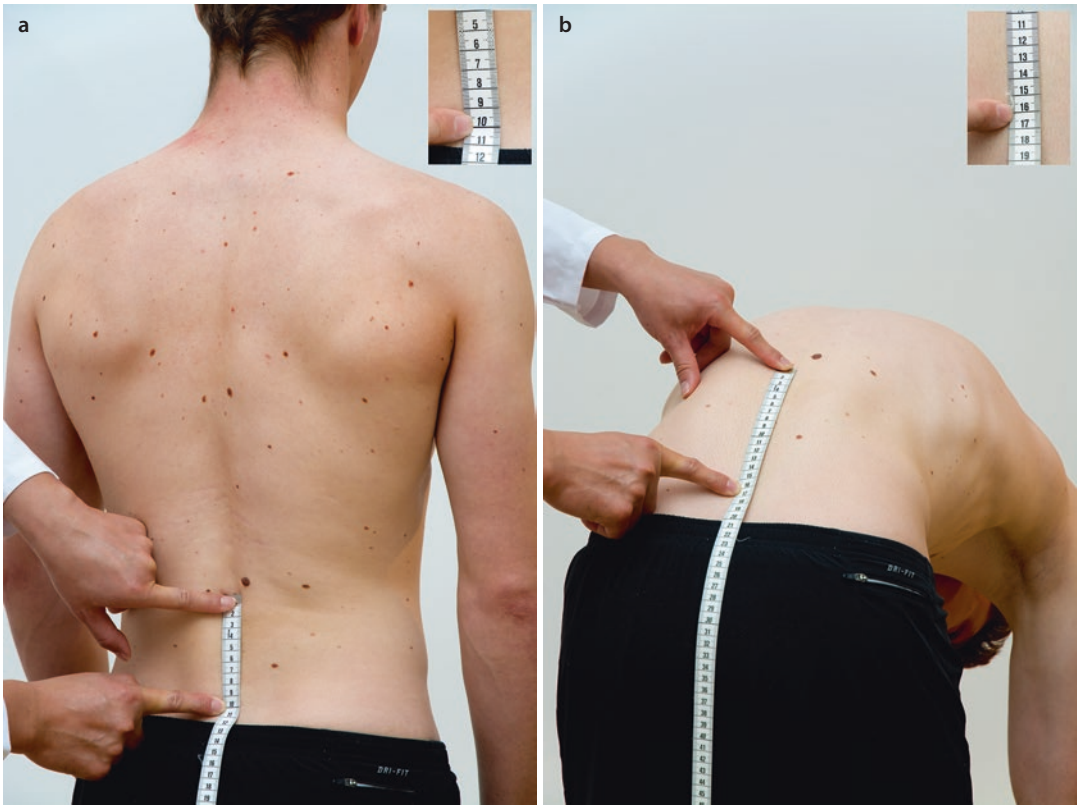


Fig. 1.28 (**a**, **b**) Schober's test: S1 and a position 10 cm cranial of this are marked in the neutral position (**a**). The distance between the two points increases during maximal flexion of the trunk and is normally about 14 cm (**b**)

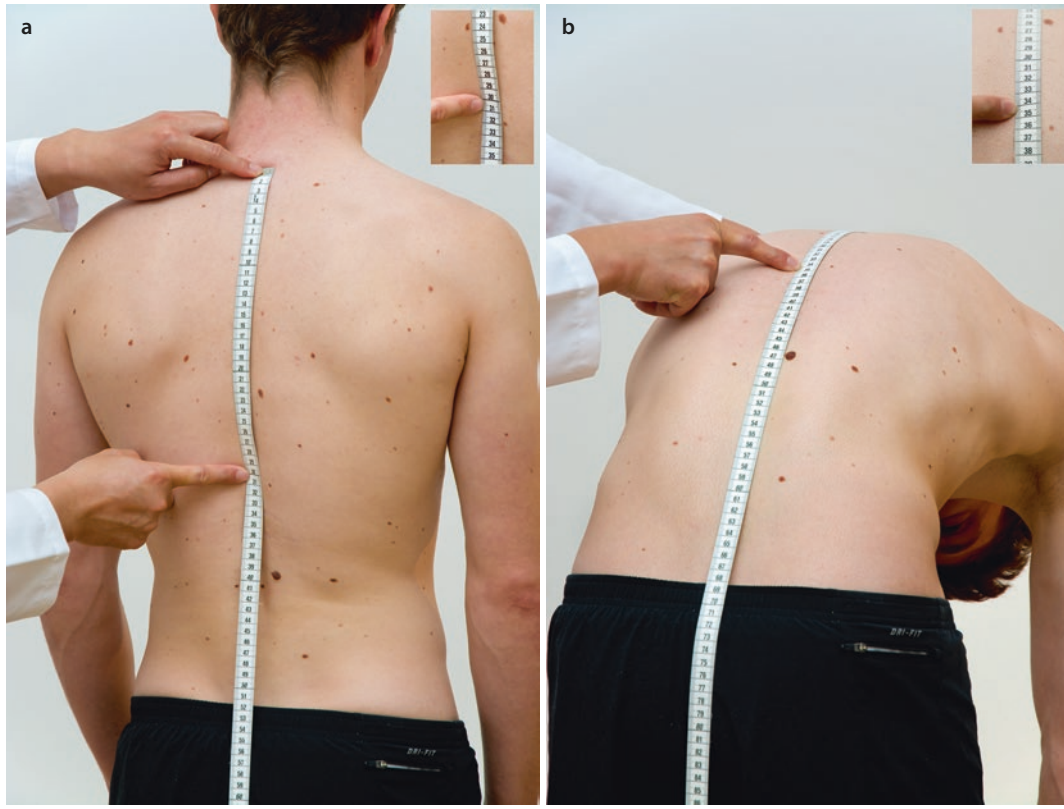


Fig. 1.29 (**a**, **b**) Ott's test: C7 is marked and a position 30 cm below C7 (**a**). The distance of the marks is normally 35 cm at maximum flexion of the upper body (**b**)

Fig. 1.30 Testing the lumbar spine reclination (normal values up to 30°)

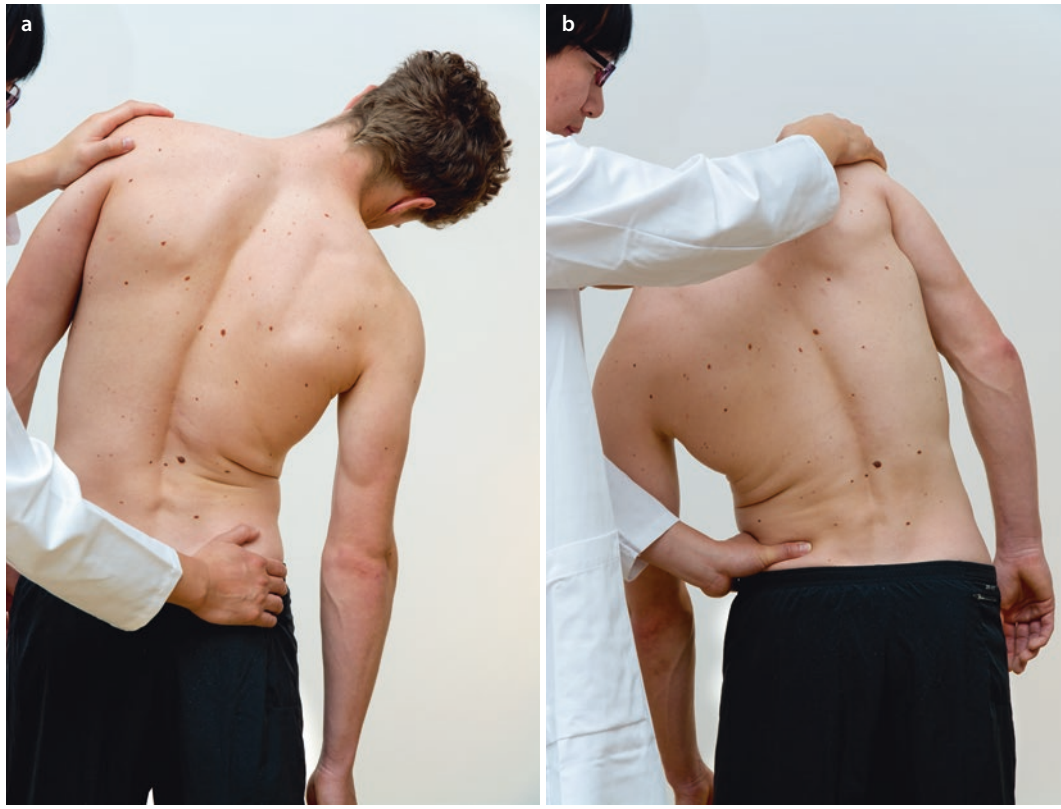


Fig. 1.31 (**a**, **b**) Testing the lumbar spine sideways tilt. Not only the angle of the tilt but also eventual blocks in the lumbar spine need to be considered [e.g., to the *right* (**a**), above L4, to the *left* above L5 (**b**)] (normal values right/left 30–40/0/30–40°)

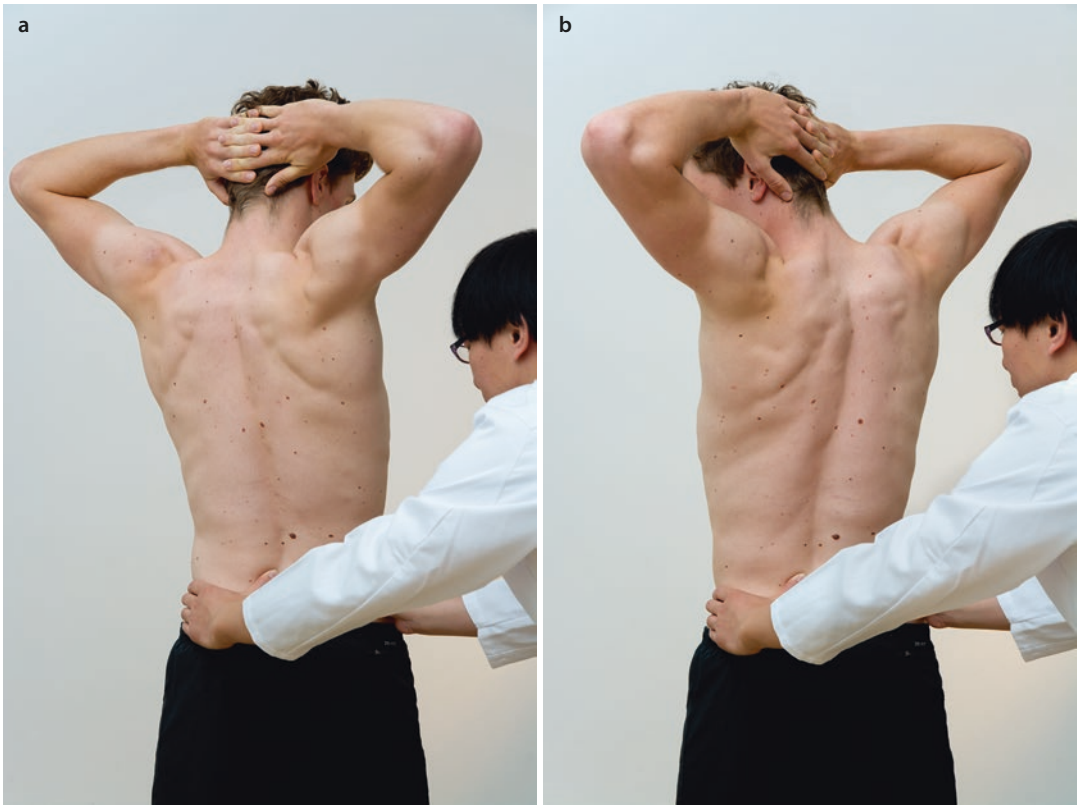


Fig. 1.32 (**a**, **b**) Testing the lumbar spine rotation. This involves fixing the pelvis, making the measurement easier (normal values right/left 30–40/0/30–40°)

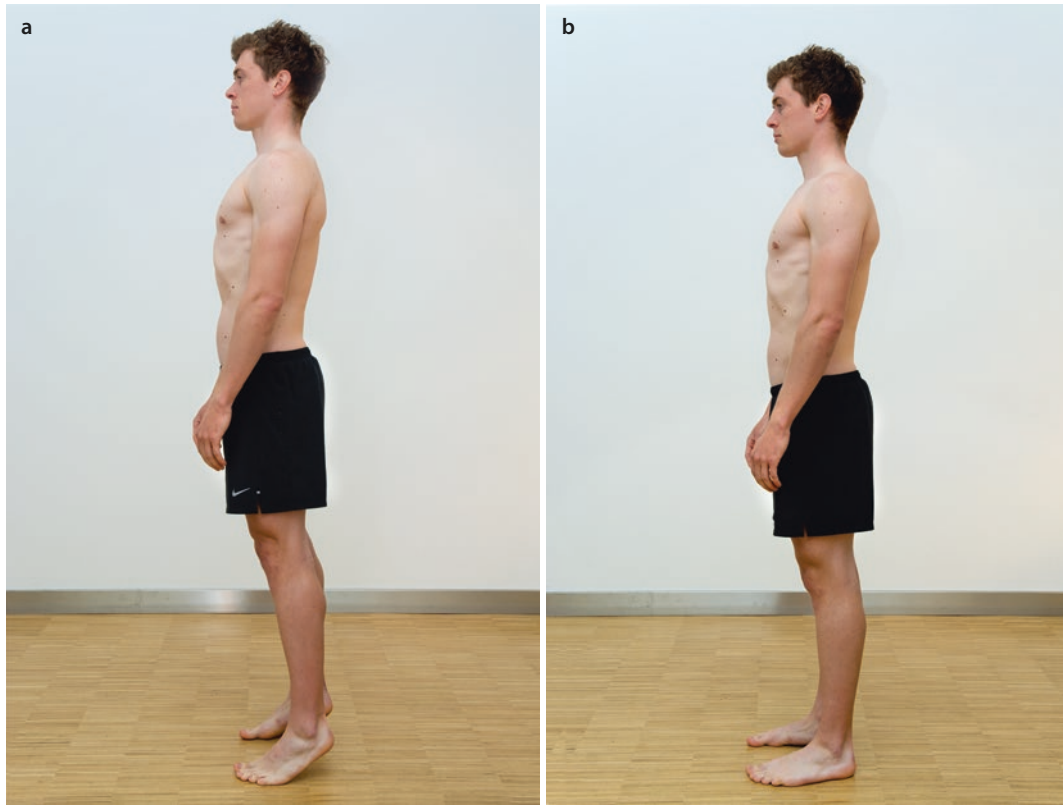


Fig. 1.33 (**a**, **b**) Heel drop pain: the patient is asked to stand on his toes (**a**) and then dropped onto his heels (**b**). The test is positive, if pain in the lumbar spine is induced by this test. It can be a sign of inflammation in the lumbar spine

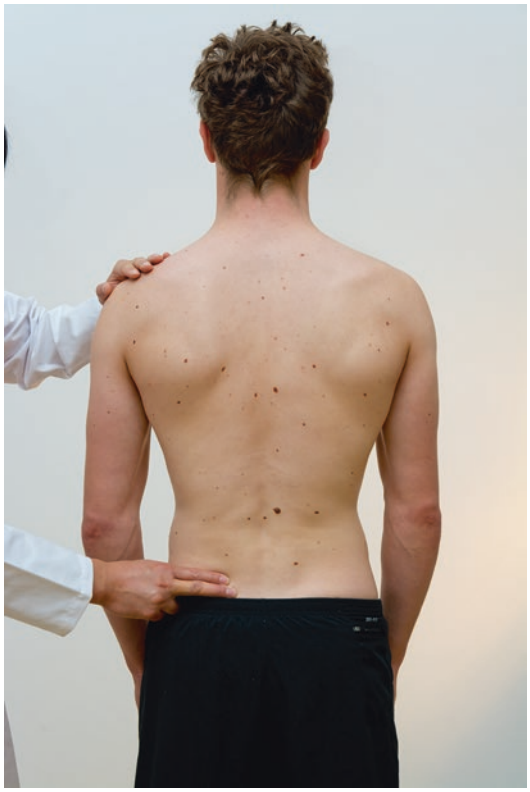


Fig. 1.34 Testing tenderness to pressure in the left sacroiliac joint

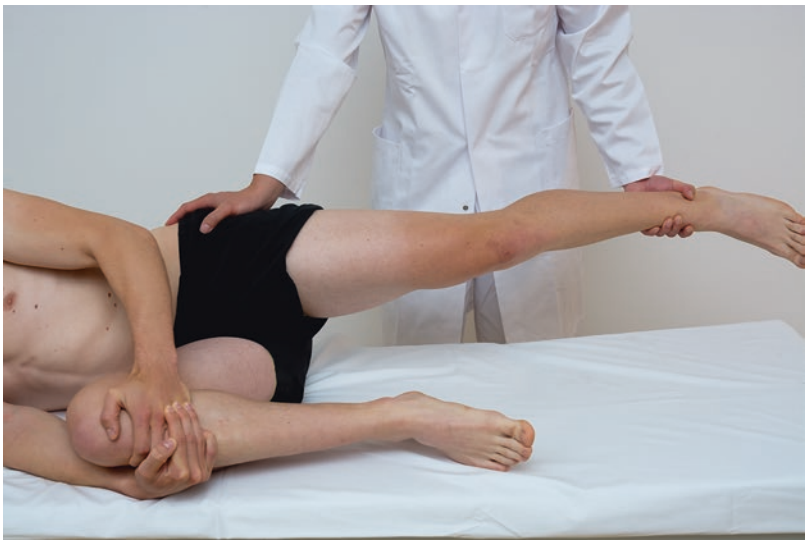


Fig. 1.35 Mennel's sign: to test for irritation to the sacroiliac joint, the Mennel test can be applied. The patient lies on his stomach or on the side. The affected sacroiliac joint and the posterior pelvic crest are fixed with one hand. The other hand extends the stretched leg further. In case of irritation in the sacroiliac joint, the leg extension will be painful

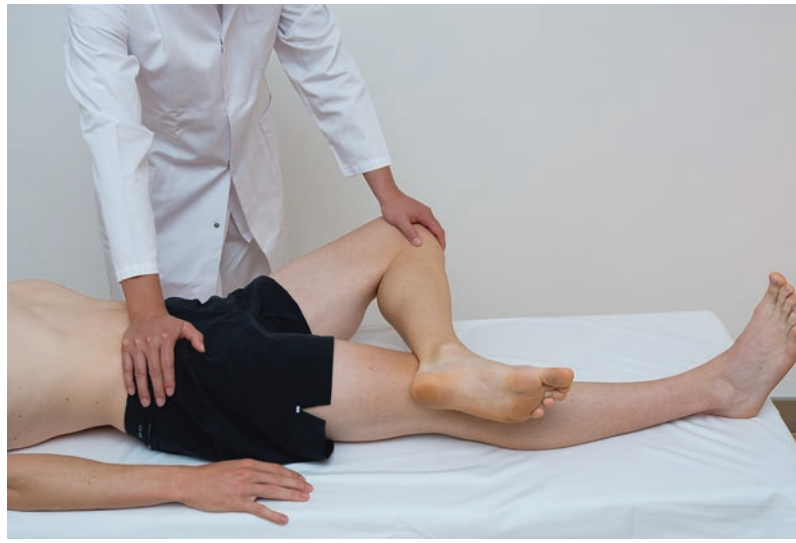


Fig. 1.36 Patrick's test: the patient lies on his/her back and bends the leg of the side that is being investigated. The flexed lower limb is adducted and placed on the opposite upper limb in order for the legs to form the shape of a "4." The investigator fixes the opposite hip and presses the knee of the affected side downward. The test is positive if downward pressure is exerted on the flexed knee while the opposite iliac crest is fixed and pain is elicited in the sacroiliac joint. A positive test points to irritation in the sacroiliac joint

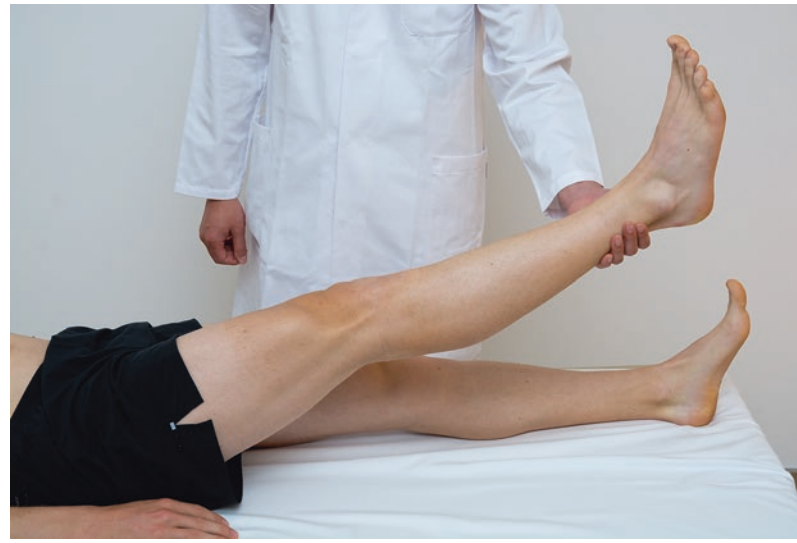


Fig. 1.37 Lasègue test (straight leg raise test) right positive at 40°. The patient lies on his back. The test is positive if the investigator elicits pain in the buttocks by lifting the leg above a certain angle

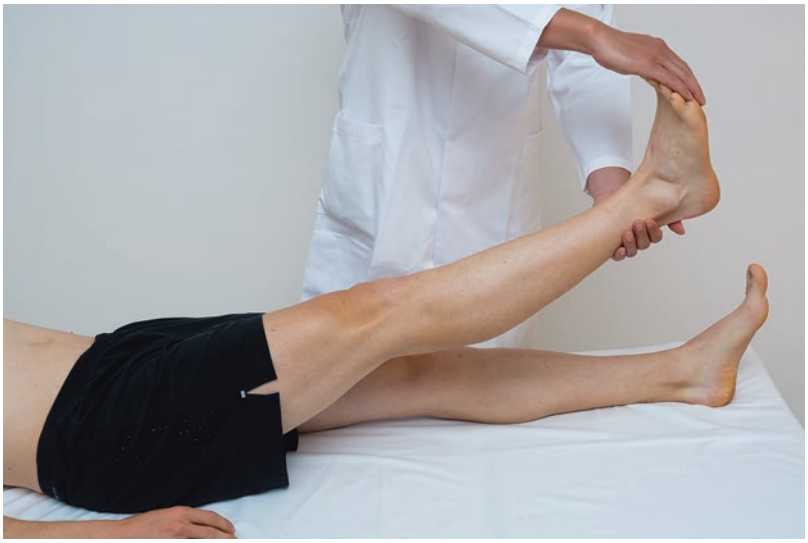


Fig. 1.38 Positive Bragard test right. If the Lasègue test is positive at a specific angle, then the passive dorsiflexion of the foot aggravates the pain

Fig. 1.39 Testing pain elicited by placing the femoral nerve under traction (reversed Lasègue) on the *right*. The patient lies on his/her stomach. The investigator elicits pain in the buttocks by raising the extended leg

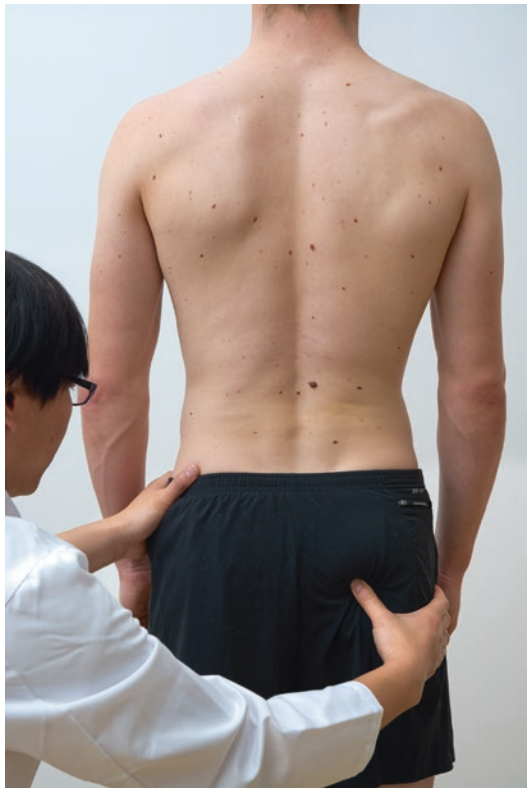
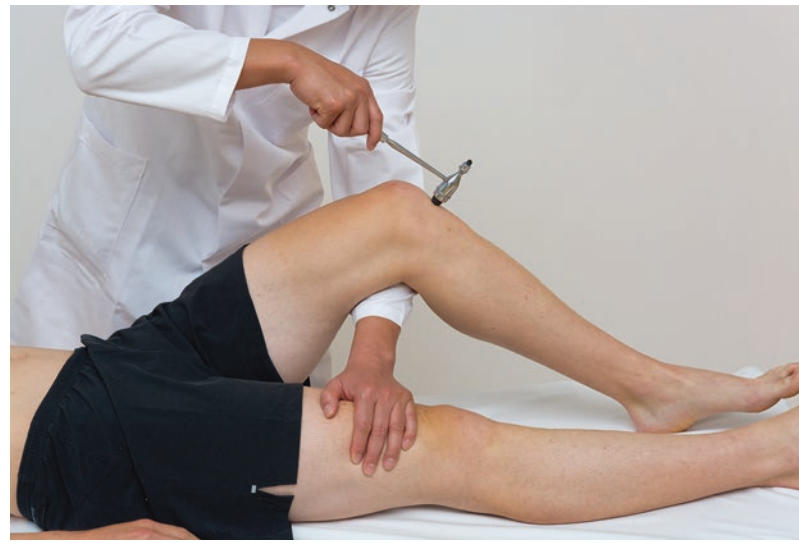


Fig. 1.40 Valleix positive on the right: tenderness in the buttocks in the course of the sciatic nerve

Fig. 1.41 Testing the patellar tendon reflex. The knee is bent slightly and the muscles are relaxed. The investigator hits the patellar tendon with the reflex hammer



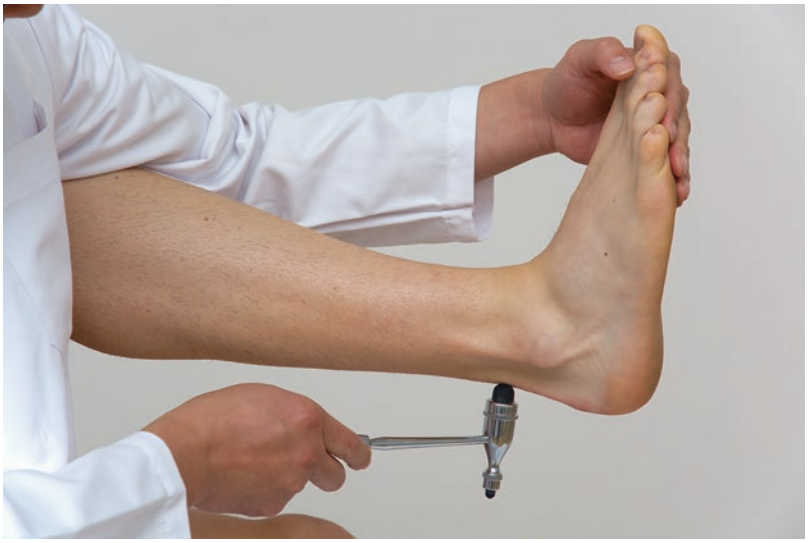


Fig. 1.42 Testing the Achilles tendon reflex. There are multiple ways of testing this reflex. Classically, the lower limb is fixed during flexion of the knee joint. The investigator holds the patient's foot with one hand and hits the tendon with the other reflex hammer in the other hand. Alternatively, the hand is placed on the sole of the foot, and that investigator strikes the hammer on his own fingers placed over the metatarsal bones of the patient

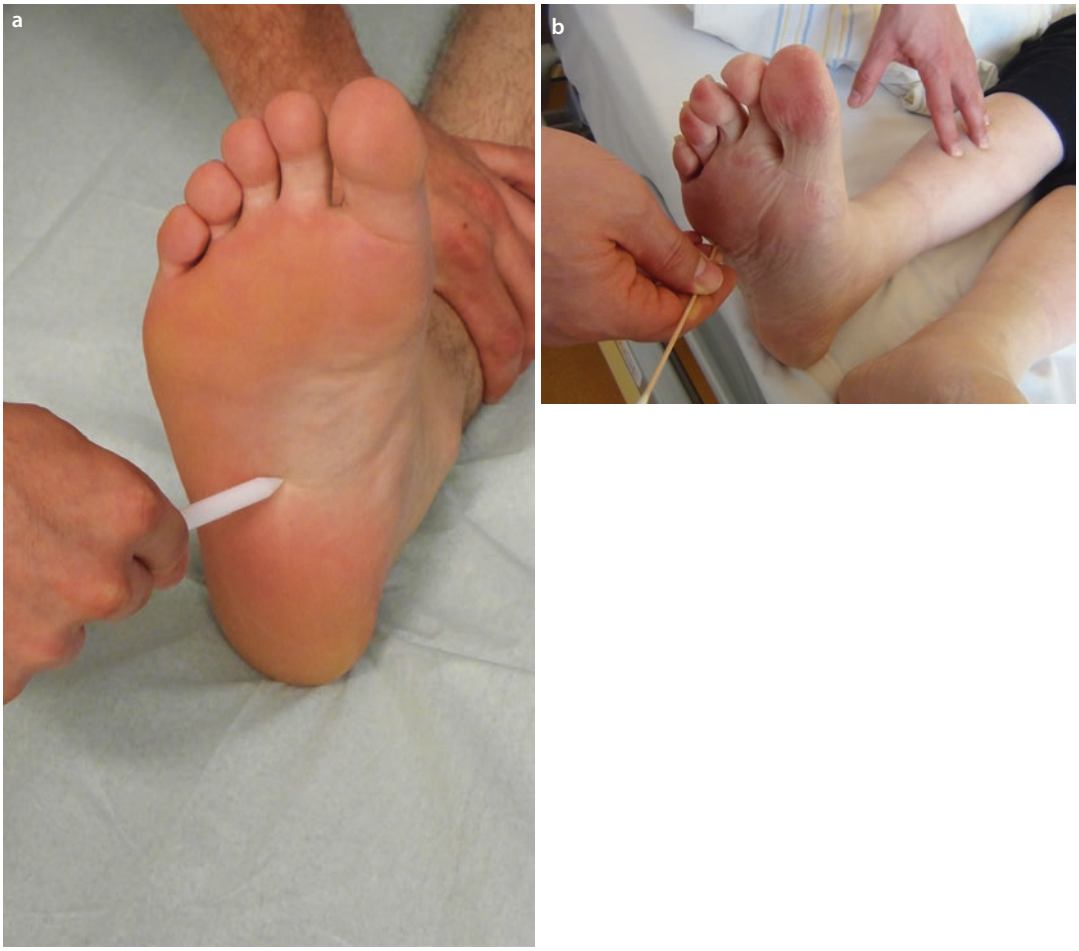


Fig. 1.43 Babinski reflex: (**a**) negative reflex (**b**) positive reflex—when rubbing the sold of the foot, the big toe extends dorsally (Image courtesy of Prof. J. Claßen, University of Leipzig)

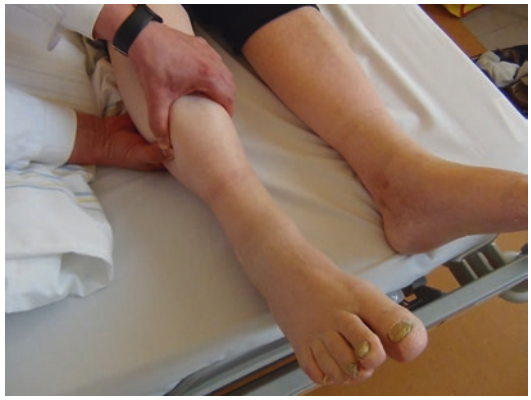


Fig. 1.44 Gordon reflex. If the test is positive, kneading the calves causes the big toe to dorsiflex. This image shows a negative test (Image courtesy of Prof. J. Claßen, University of Leipzig)

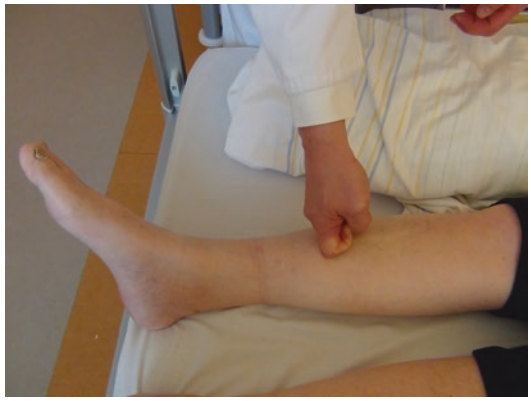


Fig. 1.45 Oppenheimer reflex. In a positive test, rubbing the front of the tibia causes the big toe to dorsiflex. In this image, the test is negative (Courtesy of Prof. J. Claßen, University of Leipzig)

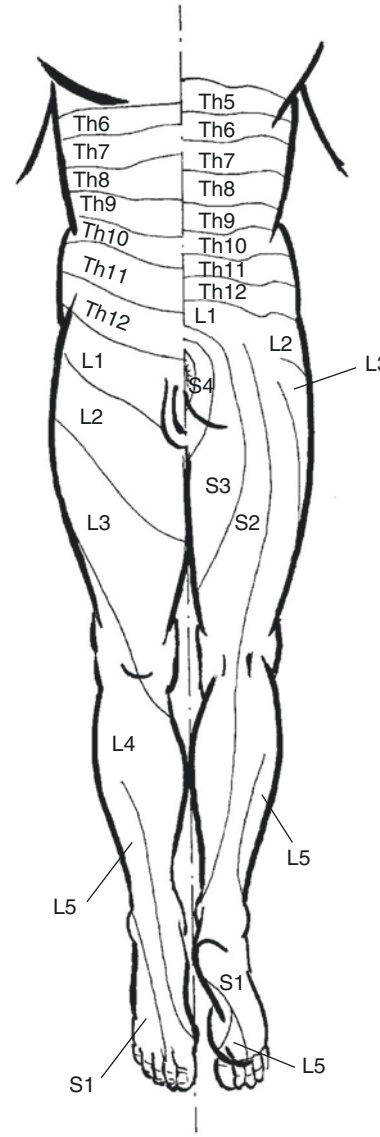


Fig. 1.46 Segmental sensory innervation of the lower limb and the trunk (frontal and posterior view)

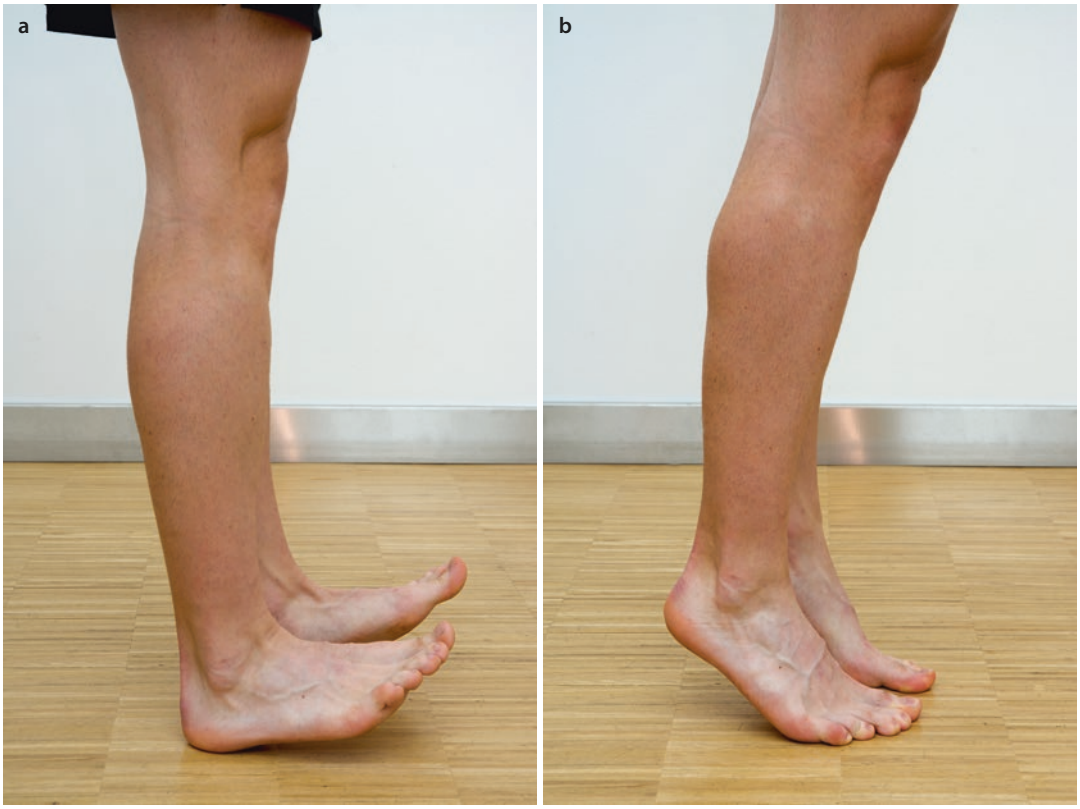


Fig. 1.47 (**a**, **b**) Testing the function of the foot dorsiflexors (L5) (**a**) and the plantar flexors (S1) (**b**)

Motor function

1.3.2 Leading Symptoms

The leadings symptoms of the thoracic and the lumbar spine are summarized in Table 1.2.

1.3.3 Disorders of the Thoracic and Lumbar Spine

- **Clinical presentation of disorders**

Tietze Syndrome

- *Describes pain in the area of the costosternal joint at the second to fourth rib.*
- *Etiology:* No single explanation. Simple blocks of the affected ribs, projected pain from inner organs, impingement syndromes of the brachial plexus, inflammation in the upper arm plexus, thrombosis of the axillar vein, retrosternal tumors (Pancoast tumor).
- *History:* Pain in the costosternal region, pain at rest, can increase during inspiration, coughing, and pressing.
- *Examination:* Localized tenderness (often localized at the height of the costovertebral joint, often diffuse, not easily locatable) localized swelling possible.
- *Diagnostics:* In case of therapy-resistant pain, X-ray of the thoracic spine in two planes. A thorough differential diagnosis should also be performed.

Postural Weakness

Active or passively fully correctable deviation of the normal posture in the spine in the sagittal plane. It is important to keep in mind that there are different postural types that are associated with different degrees of pronouncement in spine curvature.

- *Etiology:* Relative weakness of the abdominal and back muscles, especially in periods of increased growth.
- *History:* Conspicuously rounded back, hanging shoulders, protruding stomach.

Table 1.2 Leading symptoms of the thoracic and lumbar spine

History	Pain	Local findings, functional tests	Sensory function disorder	Motor function disorder	Points to
Back pain possible, otherwise rather uncharacteristic	Local pain at the costosternal transition, at the second–fourth rib	Local swelling at the costosternal transition at the second–fourth rib, local tenderness corresponding to the costovertebral joint	None	None	Tietze syndrome DD: visceral disease, impingement syndrome, thrombosis axillary vein, Pancoast tumor
Low back pain, sciatica, slow onset of low back pain	Diffuse, deep-seated pain; partially radiating; not segmentally assignable	Sideward bending unilaterally restricted; tenderness on posterior iliac crest, at anteflexion especially anterior; pseudo-Lasègue positive	Dysesthesia on the buttocks, lateral thigh, not segmentally assignable	None	Pseudoradicular pain syndrome (degenerative disease of the lumbar spine DD: recess stenosis)
Low back pain, sciatica	Radiating, stabbing pain, segmentally assignable, coughing, sneezing, and pressing pain	Overhang of the lumbar spine on the healthy side; Valleix and Lasègue positive, Bragard positive	Possible, always segmental; dorsal step and toe (L5), at the lateral border of the foot and at the little toe (S1)	Possible, weakness of the dorsiflexion muscles of the foot and the big toe (L5), weakness of the plantar flexion muscles (S1)	Radicular syndrome DD: recess stenosis
Surgical treatment of a herniated disc	Unchanged or even increased pain compared to the preliminary examination	Limited mobility, pos. Lasègue or pseudo-Lasègue	Possible, segmental	Possible, segmental	Postnecleotomy syndrome DD: relapse incident
Low back pain, sciatica	Burning pain, depending on the load	Rapid pain relief by anteflexion and lying down	Hardly	Hardly	Spinal claudication
Lumbago, sciatica, athletes	Localized pain, rarely radiates	Hyperlordosis of the lumbar spine or staging of the spinous processes, in children partially stretched lifting legs and buttocks possible	Not always, sometimes depending on the load	Hardly	Spondylolisthesis

Low back pain, thoracic pain, bacterial infection, surgical spinal disc surgery, feeling very ill, fever, fatigue, weight loss	Dull, partly stabbing pain, nocturnal pain	Posture, lumbar lordosis decreased, local tenderness, heel drop test elicits pain	Possible	Possible, bladder and urinary tract disorder	Spondylodiscitis/spondylitis
Thoracic or lumbar pain, old primary lung infection, contact with TB patients, fatigue, night sweats	Localized pain, also radiating, nocturnal pain	Partly hyperkyphosis or gibbus of the thoracic/ lumbar spine, local tenderness and pain, tenderness to striking, myogelosis, restricted mobility	In case of spinal canal narrowing	Early paralysis possible, with long histories also of late paralysis	Spondylitis tuberculosa
Lumbago, low back pain, thoracic pain; possibly iridocyclitis	Local pain, stinging, sometimes dull, early morning pain "chases" the patient out of bed!	At the beginning often positive sacroiliac joint symptoms, coughing, sneezing, pressing pain, later reinforced hyperkyphosis of the thoracic spine and lower respiratory width	None	None	Spondylitis ancylosans
Acute thoracic pain, lumbago, low-energy accident or no accident, hyperkyphosis thoracic spine	Localized pain, stinging (thoracic or upper lumbar spine), pain influenceable by breathing	Possibly increased kyphosis, sometimes Christmas-tree phenomenon, mobility restricted, local tenderness to pressure and to striking	None	None	Compression/vertebral wedge fracture (osteoporosis, DD: tumor/metastasis)
Conspicuous lateral deflection of the spine in infants	None	C- or S-shaped lateral bend in the spine, passively and actively uncorrectable	None	None	Infant scoliosis
Lateral deflection of the spine; acute sciatica or leg shortening	Possibly radiating pain in the leg	Lateral deflection completely erectable with analgesics or compensates for the shortening of the leg	Possible in herniated disc	Possible in herniated disc	Functional scoliosis

(continued)

Table 1.2 (continued)

History	Pain	Local findings, functional tests	Sensory function disorder	Motor function disorder	Points to
Lateral deflection of the spine, usually children or teenagers, rarely neurological or myopathic disorders	Often no pain, later local pain, also radiating pain	C- or S-shaped curvature of the spine, not completely erectable, rib hump or lumbar bulge on the concave side	Dysesthesia or slightly segmental damage in severe cases (rare!)	Slight damage possible in severe findings (rare!)	Structural scoliosis
Low back pain, loss of appetite, weight loss, nocturnal sweating, known malignancy	Often uncharacteristic, localized/diffuse pain, but also radiating, segmental, nocturnal pain	Local tenderness to pressure and striking	Possible	Possible over time	Primary tumors and metastases of spine

- *Examination:* Increased kyphosis of the breast (Fig. 1.17). Actively correctable into an erected position. Matthias' test (Fig. 1.25) positive (arm-raising test: upright stance, arms are raised and held in front of the body. In case of insufficient core muscles, the upper body will fall backward after 30 s to keep the arms up. The lumbar lordosis increases). When crawling in the quadripedal position, on the knees, kyphotically fixed spine segments can be visualized when the patient moves from holding the legs tight to slowly moving the arms to the front on the floor (Fig. 1.18).
- *Diagnostics:* X-ray of the thoracic and lumbar spine in two planes in case of suspected Scheuermann's disease (differential diagnosis).
- *DD:* Scheuermann's disease.

Functional Scoliosis

Non-fixed, fully compensable sideways curvature of the spine.

- *Etiology:* Can occur in the lower back pain and pelvic obliquity.
- *Examination:* Sideways curvature in the spine. In case of pelvic obliquity actively correctable by compensating for the difference in leg length. In case of lower back pain, sufficient pain therapy is often enough.
- *Diagnostics:* X-ray of the thoracic and lumbar spine in two planes, if structural scoliosis is suspected (DD).
- *DD:* Structural scoliosis

Infant Scoliosis

Partly fixed, mostly C-shaped sideways curvature of the spine in infants without torsion. No structural changes are present.

- *Etiology:* Disturbed neuromuscular development leading to unilateral contraction of the core muscles.
- *History:* Sideways curvature of the spine.
- *Examination:* Mostly C shaped, sometimes also S shaped, curvature of the spine. Neither passively nor actively correctable.
- *Diagnostics:* X-ray of the spine a.p. to rule out anomalies of the spine (e.g., hemivertebrae).
- *DD:* Infantile scoliosis (during the first 3 years). Congenital scoliosis (in combination with other anomalies).

Structural Scoliosis

Fixed sideways curvature of the spine with torsion.

- *Etiology:* Largely idiopathic. Neurological and myopathic disorders are rare as the cause. Primary and secondary bone disease as well as dermatological disorders should be considered.
- *History:* Mostly symptom-free in childhood and young adulthood (often incidental finding in the ages of 10–12 years). With increasing age, localized pain, later radiating pain. Sensory function loss, sometimes also motor function loss. The history is largely determined by mechanical damage to the function of inner organs (especially heart and lungs).
- *Examination:* Mostly C- or S-shaped sideways curvature of the spine (thoracic, thoracolumbar, lumbar, combined, right convex, left convex (Fig. 1.20)). Unilateral elevated shoulder (Figs. 1.20) shortening of the leg of 1–1.5 cm, hump of the ribs and Lumbar bulge (Fig. 1.21). The spine mostly deviates to one side from the perpendicular line drawn from C7 to S1 (Fig. 1.21). Depending on the degree of fixation, the scoliosis can be compensated actively. This can also be seen in checking the sideways curvature on both sides (Fig. 1.31). To be able to determine diseases progression, body height and arm span need to be recorded.
- *Diagnostics:* X-ray of the spine a.p. in standing position (with the pelvis). Determination of the curvature according to height and sideways direction. Degree of axis deviation (Cobb). Rotation (Nash and Moe). Skeletal maturity (stage of iliac apophysis ossification, i.e., Risser's sign). Lateral X-ray to determine the curvature in the sagittal plane. Lung function tests should also be performed in severe cases.
- *DD:* Functional scoliosis.

Chronic and Acute Low Back Pain

- *Etiology:* All differential diagnoses of degenerative disorders of the lumbar spine. Due to this, these terms should not be used independently but always in combination with the underlying diagnosis, which describes the disorder.
- *DD:* Frequently occurs in pseudoradicular syndrome. Also typical for radicular pain syndrome and root compression syndrome.

Lumbosacral Radiculopathy and Sciatica

Lumbosacral radiculopathy describes lower back pain that radiates into the leg. Sciatica describes isolated leg pain in the course of the sciatic nerve. The etiology and use of these terms is similar to chronic and acute low back pain.

Coccygodynia

Pain affecting the tailbone (coccyx)

- *Etiology:* Trauma, gynecological disorders, intervertebral disc disorders, inflammation, tumors.
- *History:* Pain especially when sitting and pressing (defecation) and during coitus. Mostly affects women.
- *Examination:* Localized tenderness at the tailbone; rectal tenderness.
- *Diagnostics:* X-ray of the coccyx in two planes and pelvis X-ray. Differential diagnosis to determine etiology (DD). Gynecological consultation, MRI or CT scans, scintigraphy.

Pseudoradicular Pain Syndrome

Pseudoradicular pain syndrome is characterized by localized or radiating pain from the spine, without any neurological deficits: the nerve roots are not affected. If the pain is caused by small vertebral joints, it is known as facet syndrome. If the pain does not radiate, it is known as vertebral or localized syndrome of the lumbar spine.

- *Etiology:* Blocks and degenerative changes in the intervertebral discs and especially in the small intervertebral joints accompanied by segmental instability. This syndrome can also develop on the basis of other degenerative disorders of the spine (failed back surgery syndrome, osteoporosis, spondylosis, spondylarthrosis, retrolisthesis, pseudospondylolisthesis, rotatory slippage, disc herniation).
- *History:* Low back pain and lumbosacral pain are common, manifesting as a diffuse, deep back pain. Pain can radiate into the buttocks, the groin, and the lower limbs.
- *Examination:* Deviation from the perpendicularity (Fig. 1.4) to the healthy side. Localized spinal process tenderness as well as paravertebral tenderness. In some cases, tenderness over the iliac spines close to the spine especially when bending forward. Ischiosacral joint dysfunction symptoms (localized tenderness (Fig. 1.34), suspension test (no suspension between ala of the ilium and the sacrum), Mennel test (Fig. 1.35), and Patrick's test (Fig. 1.36)) mostly positive. If the Lasègue test (Fig. 1.37) is positive, the hip can be flexed further by pulling at the extended leg, which could alleviate pain (pseudo-Lasègue). Reduction of lumbar lordosis alleviates pain.
- *Sensory disorders* are often located in round to oval-shaped regions with dysesthesia, mostly at the buttocks and the lateral upper limbs. Segmental specification is not possible.
- No *motor* deficits.
- *Reflexes* normal.
- *Diagnostics:* X-ray of the lumbar spine in two planes
- *DD:* All etiologically relevant disorders.

Radicular Pain Syndrome and Motor, Sensory, and Motorsensory Radicular Syndrome (Root Compression Syndrome)

The radicular pain syndrome is characterized by a segmental pain distribution along the dermatomes. Depending on whether sensory, motor, or sensory and motor deficits are present, the terms radicular or root compression are used.

- *Etiology:* Mechanical compression of the spinal nerve, mostly caused by intervertebral disc herniation, less commonly by protrusion.
- *History:* Sudden pain in the lumbar spine or radiating into the leg. Pain when coughing, sneezing, or pressing. In some cases, segmental dysesthesia. Segmental muscle weakness possible.

Saddle dysesthesia accompanied by bladder or bowel dysfunction should raise suspicion of a cauda equina compression by a prolapse (conus–cauda syndrome)! This is an emergency that should be operated within hours to prevent irreversible damage.

- *Examination:* Often the lumbar spine hangs toward the non-affected side (altered posture, scoliosis, also functional scoliosis following leg shortening). Tenderness over the lumbar spine. Valleix points (Fig. 1.40) painful on the affected side. Paravertebral increased muscle tone that can also lead to extension stiffness of the lumbar region (when the extended legs are raised at the feet, the buttocks are automatically raised too). There is a painful reduction in

mobility. When testing the fingertip-to-floor distance, there is a sideways tilt to the healthy side. A sideways tilt is not possible, or only partly possible below the affected segment on the painful side (Fig. 1.31). Lasègue (Fig. 1.37, raising the extended legs when lying on the back is painful at 10–60° in the hips) is positive when the roots of L4, L5, or S1 are affected. The Bragard sign is also positive (Fig. 1.38, testing Lasègue's sign with additional dorsal extension of the foot causing radiating pain). If L3 is affected, the reversed Lasègue sign (Fig. 1.39, raising the extended leg while the patient lies on his stomach) is positive. In case of central herniation, a crossed Lasègue's sign is possible.

- *Sensory deficits* (Fig. 1.46) are found in the dermatomes supplied by the affected roots. The back of the foot and the large toe indicate a lesion of L5; the outer margin of the foot and the small toe indicate a lesion of S1.
- *Motor deficits,* weakness in the foot and large toe dorsiflexion indicate a lesion of L5. Weakness in plantar flexion of the foot indicates a lesion of S1 (Fig. 1.47).
- *Reflexes* are weak or absent. This can also be the only neurological sign of root damage. The Achilles reflex (Fig. 1.42) corresponds to S1, the posterior tibial reflex to L5, and the patellar reflex to L4 (Fig. 1.41).
- *Diagnostics:* X-ray of the lumbar spine in two planes (exclusion of bony disorders). CT, MRI (localization and extent: level, mediolateral, lateral, medial, intraforaminal. DD). Neurological consultation.
- *DD:* Recess stenosis (neurological deficits rare), Lyme's disease, spondylolisthesis, pseudospondylolisthesis, spinal canal stenosis, inflammation, tumors.

Failed Back Surgery Syndrome (FBSS)

Continued pain after intervertebral disc operation.

- *Etiology:* Insufficient decompression, overlooked recess stenosis, wrong level operated on, osteosynthesis incorrect, wrong cause of pain, instability, scarring, recurrent herniation, hematoma, inflammation, cerebrospinal fistula. Psychological aspects are also important.
- *History:* Postoperatively unchanged or increased pain, similar to pseudoradicular or radicular syndrome. Also mixed pain.
- *Examination*: Depending on the underlying disorder, positive orthopedic findings are collected. A thorough history is essential.
- *Diagnostics:* X-ray of the lumbar spine in two planes as well as sideways functional imaging to rule out instability. Eventually functional myelogram, MRI (in some cases with gadolinium to illustrate scarring) and CT (recess stenosis), scintigraphy (especially in inflammatory process).
- *DD:* All etiologically relevant disorders must be ruled out.

Spinal Stenosis

Pain, sensory disorders, and motor function deficits (rare) that are increased during walking and alleviated during pausing or bending forward. Especially affects the lumbar spine, less common in the thoracic and cervical spine (there mostly chronic cervical myelopathy)

- *Etiology:* Constriction of the spinal canal, mostly due to degenerative alterations. Congenital stenosis is rare.
- *History*: Chronic low back pain and sciatica. Sometimes burning sensation and weakness in the legs. Symptoms are aggravated by increased lordosis and walking. Typical is a rapid alleviation of symptoms by bending forward, sitting, and lying down (decrease in lordosis of the lumbar spine).
- *Examination:* Paravertebral muscle tone increased; localized tenderness over the lumbar spine, tenderness over the sacroiliac joint and the sacral spine; Lasègue and Valleix negative (Figs. 1.37 and 1.40); reduced mobility in the lumbar spine (Figs. 1.27, 1.28, 1.29, 1.30, 1.31, and 1.32). Neurological deficits rare and less pronounced. Peripheral pulses are palpable. Positive bicycle test: symptom aggravation after 10 min on the bicycle ergometer. Rapid alleviation by bending forward despite further cycling.
- *Diagnostics:* X-ray of the lumbar spine in two levels (spinal canal in the lateral radiograph >12 mm). MRI or ST (e.g., protrusion or herniation). Functional myelography (increased stenosis during extension). In some cases, neurological consultation (determination of the affected levels).
- *DD:* Polyneuropathy, disc herniation or protrusion, inflammation, tumors, coxarthrosis.

- **Congenital malformations and metabolic disorders**

Pigeon Breast (Pectus Carinatum)

Keel-shaped protrusion of the sternum

- *Etiology:* Excessive growth of the cartilage of the ribs. Protrusion of the sternum. Increased familial prevalence, yet exact genetics still unknown. Also present in mucopolysaccharidosis, Marfan's syndrome, and thoracic emphysema.
- *History:* Asymmetric protrusion of the sternum or other parts of it. Lung or heart functions are not affected.
- *Examination:* Protrusion of the ventral thorax wall and/or the sternum (Fig. 1.22).
- *Diagnostics:* X-ray of the thorax a.p. and lateral. Photo documentation.

Pectus Excavatum

Carved-in appearance of the ventral chest wall

- *Etiology:* Congenital.
- *History:* Pectus excavatum develops in the first years of life. Boys are more commonly affected. Only in severe cases will lung and heart function be impacted. Can also occur in Marfan's syndrome, Poland syndrome, and fetal alcohol syndrome.
- *Examination:* Sunken ventral chest wall and/or sternum (Fig. 1.23).
- *Diagnostics:* X-ray of the thorax a.p. and lateral. Lung function exam, stress ECG, photo documentation.

Spondylolisthesis

Ventral displacement of a vertebra over the vertebra below it. The cranial articular and transverse processes are anatomically normal and connected to the lower vertebra. The pars articularis often shows defects (spondylosis).

- *Etiology:* Congenital.
- *History:* Mostly asymptomatic. Depending on the degree of displacement, lower back pain and/or dysesthesia (more common) can occur. Sciatica can also be present with sensory and motor deficits. Common in professional athletes.
- *Examination:* Localized spinal process tenderness in the lower lumbar spine. Increased muscle tone in the paravertebral muscles. Palpable variation in height between the two vertebrae depending on the degree of displacement. In children lumbar extension stiffness (the buttocks are automatically raised as well when the extended legs are raised from the ground).
- *Diagnostics:* X-ray of the lumbar spine in two planes (lateral determination according to Meyerding grades I–IV; full dislocation: spondyloptosis) and semi-oblique (spondylolysis).

Paget's Disease

Disease of the bone, affecting one or multiple bones with increased, uncoordinated activity of the osteoclasts and osteoblasts. This leads to formation of weak bone tissue that cannot sufficiently bear stress. Most common sites affected are the pelvis and the lumbar spine. The skull, femur, and tibia may also be affected.

- *Etiology:* Unknown.
- *History:* Often symptom-free. Depending on the extent of disease, patients may complain of localized or diffuse bone pain. Neurological deficits are possible, yet rare, when the lumbar spine is affected. Limbs can become misshapen and deformed; the head size can increase. Deafness can also occur if the 8th cranial nerve is compressed.
- *Examination:* Mostly without any characteristic finding. Localized tenderness. Increased muscle tone over the paravertebral muscles. Neurological deficits are rare. Malformation of the bones occurs if the lower limbs are affected that can also be accompanied by skin that is warm to touch. Leontiasis ossea (lion's face) can present if the skull is affected. Loss of hearing and in rare cases vision loss may occur if the skull is affected.
- *Diagnostics:* X-ray of the lumbar spine (or the affected limb) in two planes. Blood works: Elevated alkaline phosphatase in serum as well as hydroxyproline and cross-links in urine.

- **Degenerative Disorders**

Osteochondrosis

Wear of the intervertebral disc affecting the neighboring lower and upper endplates. Leads to instability of the segment. This leads to an increased subchondral sclerosis of the lower and upper endplates as well as to development of marginal spondylophytes (spondylosis).

Spondylosis

Instability causes bony osteophytes to be formed on the margins of the vertebra. In severe cases it can come to fusion of the spondylophytes.

Spondylarthrosis

Arthrosis of the small intervertebral joints.

Retrolisthesis

Dorsal displacement of one vertebra over another.

Pseudospondylolisthesis

Ventral displacement of one vertebra over another without pre-existing spondylosis.

Rotatory Displacement

Involves a sideways displacement of the vertebra against each other.

Intervertebral Disc Protrusion

Protrusion of an intervertebral disc into the spinal canal.

- *Clinically* this disorder manifests as acute low back pain that can also manifest as chronically recurring lower back pain or sciatica.
- *Examination:* Depending on the localization, tenderness can be present at the thoracic or lumbar spine and at the sacroiliac joint (Fig. 1.34) as well as around the paravertebral muscles. Myogelosis can occur in the paravertebral muscles. A stiffening of the muscles is also possible and mobility is generally limited. Sideways tilting is only partly possible (often unilaterally) in the upper levels of the lumbar spine. The lower segments remain steep (Fig. 1.31). A rotatory pain is often found.
- *Sensory function:* Segmental deficits are rare. More common are dysesthesia that cannot be allocated to exact segments.
- *Motor function:* No deficits.
- *Diagnostics:* X-ray of the lumbar spine in two planes. In case of therapy resistance MRI or CT scan.
- *DD:* Intervertebral disc prolapse, Lyme's disease, inflammation, tumors etc.

Lumbar Disc Herniation

In spinal disc herniation, the soft inner part of disc tissue (nucleus pulposus) bulges out through a tear in the fibrous ring (annulus fibrosis) or the posterior longitudinal ligament into the spinal canal. The herniation can be medial, mediolateral, and lateral. If the herniated nucleus pulposus completely exits the annulus fibrosis, it is called a "sequestered disc."

It can come to nerve compression. The history and examination reflect a radicular pain or root compression syndrome.

Scheuermann's Disease

Skeletal growth disorder in childhood affecting the upper and lower endplates. Commonly seen in the thoracic spine, less commonly also in the lumbar spine.

- *Etiology:* Unknown.
- *History:* Pain is not always present. Increased kyphosis of the thoracic spine (hunchback) or a flattened lordosis of the lumbar spine (Figs. 1.14, 1.15 and 1.16). Back pain and lower back pain especially upon stress.
- *Examination:* Tenderness at the thoracic and lumbar spine. Weak paravertebral muscles. Fixated kyphosis of the thoracic spine (Fig. 1.17). When the patient, on all fours, moves from making his/her body into a tight ball to slowly moving forward with his/her arms on the examination table or floor, the segmental kyphosis or the decreased lordosis becomes visible (Fig. 1.18).
- *Diagnostics:* X-ray of the thoracic spine or the lumbar spine in two planes (Schmorl's nodes in the affected endplates, at least three wedged vertebrae).
- *DD:* Postural weakness

Diffuse Idiopathic Skeletal Hyperostosis (Forestier's Disease)

Spiny ankylosis caused by spondylophytes, mostly affecting the thoracic spine. Accompanied by enthesopathy of the pelvic ligaments and the heel ligaments. Primarily a radiological diagnosis.

- *Etiology:* Largely unknown. Significant correlation to diabetes, hyperlipidemia, gout, atherosclerosis, hypertension.
- *History:* Mostly male patients older than 60. Often fixated hyperkyphosis of the thoracic spine. Local and radiating pain. Often combined pain syndromes of the complete spine.
- *Examination:* Increased fixed kyphosis of the thoracic spine possible (Figs. 1.17 and Fig. 1.18). Localized tenderness. Limitation of the chest circumference when breathing (Fig. 1.26). The

mobility of the lumbar and thoracic spine is not decreased. Localized dysesthesia may occur. No motor function deficits.
- *Diagnostics:* X-ray of the lumbar spine and the thoracic spine in two planes (presence of spondylophytes between the vertebrae).
- *DD:* Bechterew's disease. Scheuermann's disease.

Baastrup's Disease, Kissing Spine Disease

Localized isolated pain syndrome of the lumbar spine caused by contact of neighboring spinal processes.
- *Etiology:* Hyperlordosis and enlarged spinal processes; thinning of the intervertebral disc spaces, increased mobility.
- *History:* Localized pain in the spinal processes of the lumbar spine. Pain during stress. Pain at rest also possible.
- *Examination:* Local interspinous tenderness. Reclination (lordosis) leads to pain aggravation.
- *Diagnose:* X-ray of the lumbar spine in two planes ("kissing spine"). Eventually lateral functional imaging (contact visible upon reclination).

Narrow Spinal Canal

Constriction of the spinal canal, mostly caused by degenerative alterations, mostly in the lumbar spine.
- *Clinically,* patients represent with spinal claudication.

Recess Stenosis

Irritation of the nerve root in the intervertebral foramina.
- *Etiology:* Degenerative alterations of the small intervertebral joints (spondylarthrosis).
- Often accompanied by disc protrusion or herniation.
- *History:* Sciatica, mostly traceable to specific segments. Pain increases under stress. Paresthesia.
- *Examination:* Stiffened paravertebral muscles. Localized tenderness at the lumbar spined and the sacroiliac joint (Fig. 1.34) and at the iliac spines. Lasègue test negative. No segmental sensory or neurological deficits.
- *Diagnostics:* X-ray of the lumbar spine in two planes.
- *DD:* Polyneuropathy; disc herniation or protrusion, pseudoradicular syndrome, inflammation, tumors, coxarthrosis.

Osteoporosis

Systemic skeletal disorder, characterized by a loss of bone mass and a weakening of the bone tissue micro-architecture leading to a reduction in bone strength and an increased predisposition to fracturing. One distinguishes between primary and secondary osteoporosis. The most common forms of primary osteoporosis are type I (postmenopausal, presenile) and type II (senile).

Secondary osteoporoses are mostly independent disorders. They will only be briefly mentioned here. Examples include inactivity-induced osteoporosis, Sudeck's disease, transitory osteoporosis of the hip joint, osteoporosis in rheumatoid arthritis, diabetes mellitus, malabsorption, dietary deficiency, hyperthyroidism, and chronic heparin medication.
- *Etiology:* Type I, estrogen deficiency; type II, aging, lack of movement, calcium and/or vitamin D deficiency. More risk factors are now known that lead to osteoporosis.
- *History:* Localized back pain, sometimes radiating into the lower extremities or into the groin. Severe, acute pain in case of osteoporotic vertebra fracture, mostly in the lower thoracic spine, without adequate trauma. Decrease in height and increased hunched back. Can also lead to other fractures, e.g., radial and hip fractures.
- *Examination:* Classic presentation with a stooped appearance, round stomach, and characteristic downward-pointing diagonal skinfolds "Christmas-tree phenomenon" (Fig. 1.19). Nowadays this full clinical presentation is rarely seen. Reduced height (greater arm span). Weak paravertebral muscles. More often rather uncharacteristic tenderness at the thoracic and lumbar spine. Strong local tenderness at a fresh fracture of a vertebra. No sensory or motor function deficits.
- *Diagnostics:* X-ray of the thoracic spine and the lumbar spine in two planes (lateral imaging: emphasis on the longitudinal trabecular stream, frame vertebra, keel vertebra). Densitometry of the lumbar spine, femoral neck, radius (reduced bone density). Laboratory: hemogram, BSR, CRP, calcium,

phosphate in serum, bone-specific alkaline phosphatase, gamma GT, eletrophoresis, creatinine clearance, TSH, 25-OH-vitamin D3, cross-links, or crosslaps.

- **Inflammatory disorders**

Unspecific Inflammation: Spondylodiscitis, Spondylodiscitis, and Spondylitis

Unspecific bacterial or aseptic inflammation of the intervertebral disc affecting the bordering vertebra (spondylodiscitis) or osteomyelitis of a vertebra (spondylitis). Acute (more common) and chronic form.

- *Etiology:* Secondary bacterial infection due to hematogenous spreading. Exogenous bacterial infection (open or endoscopic disc operation, discography, chemonucleolysis) and aseptic inflammation by laser decompression.
- *History:* Bacterial infection is common or operative procedure on the disc. Fatigue, weight loss, and septic temperatures (acute form). Dull, sometimes strong, sharp back pain. Nocturnal pain.
- *Examination:* Relieving posture, reduced lordosis of the lumbar spine, increased muscle tone in the paravertebral muscles, localized tenderness, heel-strike pain (Fig. 1.33). Neurological deficits can occur.
- *Diagnostics:* Laboratory (BSR and CRP elevated, leukocytosis). In case of fever, blood cultures should be completed. X-ray of lumbar spine and thoracic spine in two planes (lateral imaging: lowering of the disc in children—spondylitis and osteolysis in the endplates—spondylodiscitis). CT, MRI, scintigraphy.
- *DD:* Specific spondylitis, Bechterew's disease, chronic polyarthritis in children, tumors.

Specific Inflammation: Spondylitis Tuberculosa

Specific inflammation in one or more vertebrae (mostly thoracic or lumbar spine) by mycobacterium tuberculosis.

- *Etiology:* Often hematogenous spreading of an old primary infection in the lung (mycobacterium tuberculosis).
- *History:* Tuberculosis of the lung is common or other known contact with persons infected with tuberculosis. Localized back pain, especially at night. Furthermore, radiating pain. Fatigue, nocturnal pain, nocturnal sweating. Slow progression.
- *Examination:* In some cases, kyphosis and gibbus deformity of the thoracic or lumbar spine. Increased muscle tone. Reduced mobility of the lumbar spine. Neurological deficits can occur.
- *Diagnostics:* X-ray of the thoracic and lumbar spine in two planes. (Paravertebral abscess, psoas shadow.) Scintigraphy, CT/MRI. Tine test. Gastroscopy. Laboratory: BSR (mildly elevated).
- *DD:* Unspecific spondylitis; Bechterew's disease; fracture, tumors.

Rheumatic Inflammation: Ankylosing Spondylitis

Chronic seronegative systemic disease of the skeleton and the joints. Destructive and proliferative processes are activated that affect the sacroiliac joint and the spine, leading to ankylosis.

- *Etiology:* Microbial antigens are being discussed. Genetic relation to histocompatibility antigen HLA-B27.
- *History:* In the initial stadium, weakness and a feeling of malady. Pain in other joints and in the heel. Iridocyclitis can be present. Chronic, deep back pain, partly similar to sciatica radiating into the lower limb. Pain is alleviated by walking.

The pain awakens the patient at night or in the early hours of the morning and drives him/her out of bed.

- In progressed disease, further stiffening of the spine, steepening of the lumbar spine, increased kyphosis of the thoracic spine. Peripheral joints may also be affected.
- *Examination:* Depending on the stage of disease: loss of lordosis in the lumbar spine, increased kyphosis in the thoracic spine. Localized tenderness at the spine and at the sacroiliac joint. Sacroiliac joint suspension test negative. Limitation of the mobility in the spine (especially of reclination in the cervical spine, Fig. 1.2). Chest expansion when breathing reduced (Fig. 1.26).
- *Diagnostics:* BSR elevated, HLA-B27 positive. X-ray of the sacroiliac joint. Thoracic and lumbar spine (syndesmophytes, later bamboo shape).

- *DD:* Seronegative spondarthritis (arthritis psoriatica, Reiter's disease), enteropathic arthritis (in Crohn's disease, ulcerous colitis, and reactive arthritis).

- **Traumatic disorders**

Injuries of the thoracic and lumbar spine are easily overlooked in polytraumatized patients. There are stable and unstable fractures. Fractures of the thoracic spine between T1 and T10 are relatively stable.

At the thoracic spine, one distinguishes among compression fracture, burst fracture, and dislocating fracture. In the lumbar spine, burst compression fractures, keel vertebra fractures, dislocating fractures, and fractures of the transverse processes are distinguished.

■ Compression and Wedge Fractures

Predominantly compression of the anterior parts of the vertebrae. This causes forward slanting of the vertebrae. In pathological fractures, the posterior part of the vertebrae is affected. This is almost never the case in osteoporotic fractures. Osteoporotic fractures are mostly stable.

- *Etiology:* Mostly osteoporosis, also pathological fractures (compression and wedge fractures of the thoracic and lumbar spine). These are caused by slight or inadequate trauma. In the case of adequate trauma, fractures of the thoracic and lumbar spine are mostly a result of a severe trauma (fall from a great height, e.g., in younger patients). These injuries are often accompanied by neurological deficits. This is especially the case in burst fractures.
- *History:* In osteoporotic wedge fractures, acute pain occurs in the thoracic and lumbar spine induced by inadequate trauma. A course of disease involving chronic pain is also common.
- *Examination: Osteoporotic or pathological fracture:* Commonly involves unspecific findings like tenderness over the thoracic and lumbar spine. Weak paravertebral muscles. No sensory or motor deficits. Severe tenderness in a new vertebra fracture. Neurological deficits are also common if acutely induced by inadequate trauma (repeat examination and documentation!).
- *Diagnostics*: *X-ray of the thoracic and lumbar spine in two planes to visualize the fracture. Neurological consultation especially if sensory or motor deficits.*

■ Dislocation Fractures

Severe injuries of the vertebrae, mostly in combination with other injuries. If the thoracic spine is affected, paraplegia is commonly the result. The prognosis for injuries affecting the lumbar spine is better as the cauda equina is more likely to be affected than the spinal cord.

■ Fractures of the Transverse Process, Rib Fractures

Rare in orthopedic examination and then mostly in a late form. Clinically inconspicuous. No therapeutic consequences.

- **Tumor disorders**

■ Osteoid Osteoma

Rare in the spine (mostly seen in tubular bones). Mostly seen in adolescents and young adults. Benign bone tumor (diameter ca. 1 cm). Central nidus (osteoid with spindle cells) and surrounding sclerosis (osteoblastosis).

- *History:* Typically presents with intense nocturnal pain (mostly low back pain and back pain). Salicylates generally serve well to reduce pain.
- *Examination:* Uncharacteristic.
- *Diagnostics:* X-ray of the lumbar and thoracic spine in two planes. Scintigraphy. MRI and CT.
- *DD:* Osteoblastoma.

■ Osteoblastoma

Affects patients under 40. Benign bone tumor. Mostly affects the spine and long tubular bones.

- *History:* Nocturnal pain is uncommon. Salicylates are not helpful for pain relief.
- *Examination:* Uncharacteristic. If the vertebrae are affected, scoliosis can be seen.
- *Diagnostics:* X-ray of the lumbar and thoracic spine in two planes. Scintigraphy. MRI and CT.
- *DD:* Aneurysmatic bone cysts, highly differentiated osteosarcoma, giant cell tumor.

■ Plasmacytoma

Most common malignant bone tumor of the spine. Commonly in those older than 50. Mostly affects the vertebrae. Characterized by abnormal plasma cells.

- *History:* Low back pain. In case of fracture, acute low back pain.
- *Examination:* No characteristic clinical findings.

- *Diagnostics:* X-ray of the lumbar spine and the thoracic spine in two planes. X-ray of the skull in two planes. Scintigraphy, MRI/CT. Laboratory: BSR (accelerated) Bence Jones proteins in urine. Eventually biopsy.

Metastases

Most common tumors in the skeleton derive from kidney cancer, breast cancer, thyroid cancer, prostate cancer, and lung cancer.

- *History:* Dependant on the extent of spreading. First sign can be a pathological vertebral fracture. This is accompanied by acute, stinging, or diffuse pain in the affected region. Radiating pain can also be found. Loss of appetite, nocturnal sweating, and weight loss may also point toward malignancy.
- *Examination:* Localized tenderness, compression pain.
- *Diagnostics:* X-ray of the thoracic and lumbar spine in two planes. Scintigraphy, CT/MRI scans. Diagnostics of the five most important primary tumors.

Further Literature

The examination of the spine, 2009 by M.T.A. Boumans, A. van Ooy

Upper Extremity

A. Roth, *Orthopedic and Trauma Findings*, DOI 10.1007/978-3-662-53147-1_2

2.1 History

2.1.1 Localization and Nature of Complaint

Pain	Localization	Circumscribed/radiating
	Character	Numb/sharp/drilling/throbbing/burning/cramp-like
	Situation	During certain movements, under load/at rest, at night
Swelling	Location/extent	
Deformity	Location/kind	Altered posture, deformity
Movement disorder	Location/kind/direction	Limitation of movement/locking/stiffness, walking distance
Sensory disorder	Location	Paresthesia/numbness/tingling/pins and needles
Motor disorder	Location/degree (extent)	Muscular atrophy
	Location/degree (M5–M0*)	Weakness/paralysis/spasticity
		Shoulder/elbow/wrist/finger Flexion/extension/abduction/abduction

*Janda's muscle strength test:
Level 5: Full movement, normal strength
Level 4: Movement possible against some resistance
Level 3: Movement possible against gravity
Level 2: Movement possible with aid, but not against gravity
Level 1: Only some muscle twitching
Level 0: No muscle twitching

2.1.2 Time Correlations

Beginning and course	Congenital/acquired (age/point in time)
	Acute/chronic
	Slowly/stably progressive
	Occurrence in flares with or without symptom-free intervals
	During the day/at night

2.1.3 Concomitant Circumstances

Accident	Yes/no	
Location	Leisure/workplace	
Mechanism of injury	Kind	Fall/working overhead/lifting a load/heavy lifting/accident
	Triggering event	No triggering event/fall/bending/rising from a squatting position Height/weight/load/persons involved
	Motor vehicle accident	Type of vehicles involved/direction/speed, angle of impact, lateral, head-on or rear-end collision, head impact/ headrest/safety belts

Preexisting conditions	Family medical history	
	Degenerative/bacteria/ rheumatic inflammatory	No/if yes: local/systemic
	Bacterial infection/viral infection	
	Traumatic/tumor	
	Malformations	
Common symptoms	Fever, weight loss (time period of weight loss), fatigue, nocturnal sweating	Yes/no

2.1.4 Existing Treatment/Past Treatment

Medication	Medication/dose/duration of intake	Localized/systemic
	Relief	Yes/no
Physical therapy	Application	Forms/duration/frequency
	Relief	Yes/no
Orthopedic aids	Walking stick/crutches Basques/bandage Brace/cast	Yes/no
Operations	Time/site/type/success	

2.2 Shoulder

2.2.1 Systematic Examination

- **Local findings**

Shoulder position/relief	Physiological/pathological (right/left)	Shoulder on equal level/elevated shoulder Protraction of the scapula Prominent acromioclavicular/ sternoclavicular joint
Swelling/redness/ hyperthermia	No; if present, then:	Localization/extent/scope
Hematoma/abrasion/ open wound/scab	No; if present, then:	Localization/extent/scope
Scarring	No; if present then:	Localization/extent (soft/rough/ displaced)
Muscles	Supraspinatus muscle/infraspinatus muscle/ deltoid muscle/pectoral muscle	Highly developed/wasted/ shortened Atrophy (significant?), muscle tone increase or decrease (right/left)

Mobility shoulder	Anteversion/retroversion Abduction/adduction External rotation/internal rotation (in neutral position, at 90° of abduction) Aprons and neck grip	––/––/–– degrees (passive/active, right/left)
Crepitation	No; if so:	Fine/coarse (left/right)
Shoulder pain	Motion pain (active/passive) Neer's impingement test Tenderness, subacromially, at the greater tuberosity, at the bicipital groove, at the coracoid	None; if yes: positive (right/left)
Rotator cuff	Painful arc Jobe test Pain during motion against resistance (external rotation, internal rotation, abduction, adduction) Outside rotation lag sign Internal rotation lag sign Belly press	Pain yes/no (right/left)
Biceps tendon	Yergason test Palm-up test	Pain yes/no (right/left)
Glenohumeral guidance	Apprehension test Posterior apprehension test Sulcus sign	Positive yes/no (right/left)
Clavicle/ acromioclavicular joint	Piano key phenomenon Finger pointing test Cross-body test (horizontal displaceability) AP displaceability	Pain yes/no (right/left)
Arm length	Lateral edge of the acromion–ulnar styloid process	--cm (right/left)
Amputation stump length	Lateral edge of the acromion—end of the amputated arm (stump)	--cm (right/left)

- **Neurology**

Reflexes	Biceps tendon (C5) Triceps tendon (C7) Brachioradialis (C6)	Right/left Vigorous/decreased/absent/ supernormal (hyperreflexic)
Sensory examination	Dermatome (segment assignable/not exactly assignable) (right/left)	Hypesthesia/paresthesia/dysesthesia
Motor function examination	Shoulder elevation (C3–C5) Shoulder abduction (C5/C6) Elbow flexion (C5/C6) Elbow extension (C7) Pronation (C6–Th1) Supination (C5/C6) Wrist extension (C6/7) Wrist flexion (C6–Th1) Wrist drop (N. radialis) Hand of benediction (N. medianus) Ulnar claw (N. ulnaris)	Right/left intact/impaired function (M0–M1–M2–M3–M4–M5)

- **Circulation**

Arteries	A. axillaris A. radialis	Fully/barely/not palpable (right/left)
Veins	Venous stasis	Present/absent (right/left)
Capillary pulse	Fingertips	Visible/invisible

2.2.2 Leading Symptoms of the Shoulder

The leading symptoms of the shoulder are summarized in Table 2.1.

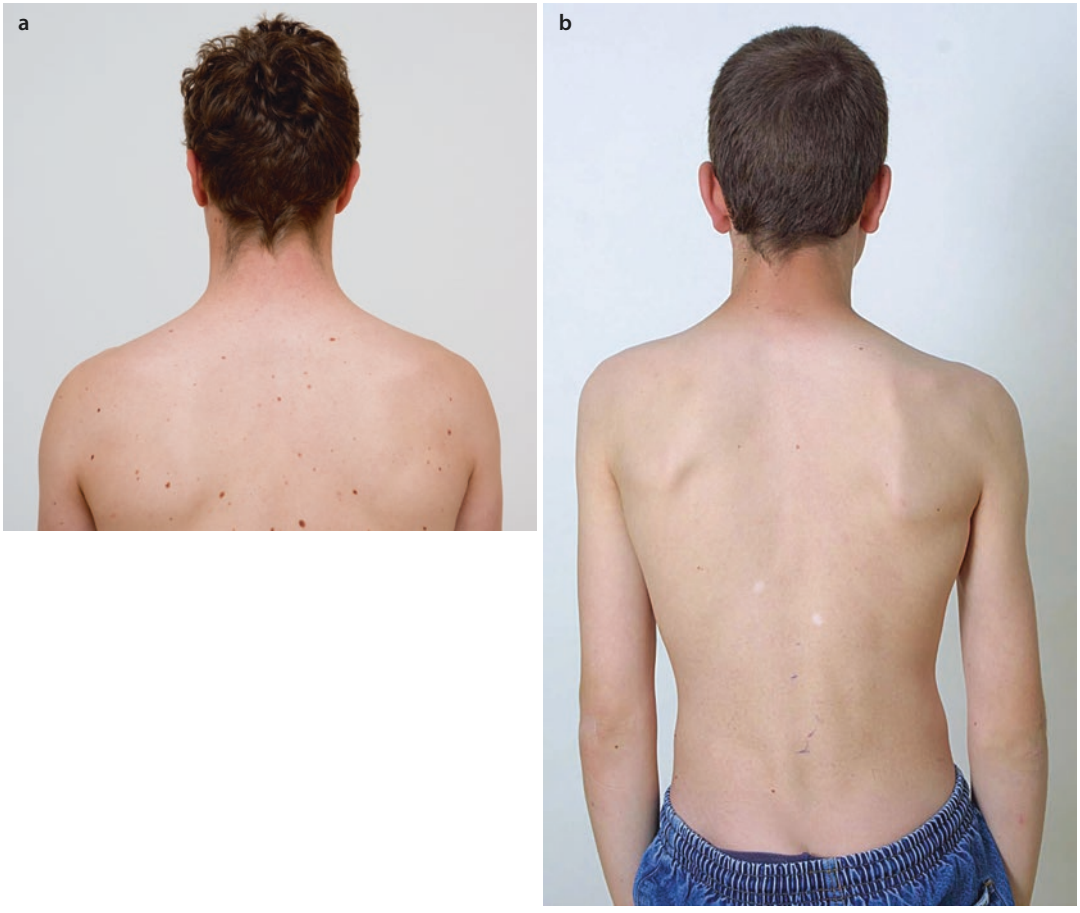


Fig. 2.1 (**a**, **b**) Shoulder symmetrical (**a**), elevated shoulder left (**b**)

Table 2.1 Leading symptoms of the shoulder

History	Pain	Local findings, functional tests	Sensory function disorder	Motor function disorder	Points to
Mostly patients older than 40 years, acute or subacute disorder	After lifting a heavy load or a fall, sudden shoulder pain or spontaneous pain at night, increasingly during the day	Weakening of the rotation and abduction (up to pseudoparalysis), positive painful arc, local tenderness, painful movement against resistance	None	None	Rotator cuff tear
Mostly middle-aged women, chronic to subacute shoulder pain	Pain at the proximal humerus	Local tenderness to pressure at the proximal humerus, possibly limiting the mobility	None	None	Calcifying tendinitis
Lesion of the rotator cuff or the biceps tendon, calcifying tendinitis (often primarily unknown), dysfunction	Guarding posture	Restriction of abduction, external rotation, and grip into the neck. Localized tenderness	None	None	Secondary frozen shoulder
Women (40–60 years). Phase alternating between pain and restriction of movement	Relatively acute pain, especially at night. Pain subsides, whereas mobility decreases	(Steadily increasing) painful limitation of movement	None	None	Primary frozen shoulder (stages 1–2)
Recurrent shoulder dislocation after primary traumatic shoulder dislocation	Pain in dislocation may be less with more frequent dislocations	Positive anterior apprehension test. Positive sulcus sign. Perhaps positive posterior Gerber	None	None	Post-traumatic recurrent shoulder dislocation

Humeral fracture, pressure injury at the upper arm	Only in trauma	Weakened grip	In the hand: hypesthesia at the thenar eminence, palm, and palmar side of the radial 3 1/2 fingers	Hand of benediction	Injury to the median nerve in the upper arm
Humeral shaft fracture. Shoulder crutch. Sleeping on a park bench. Weakness in the arm and hand	Only if trauma	Free passive mobility, active dorsiflexion not possible in the wrist	Hypesthesia radial/posterior to 2 1/2 fingers	Drop wrist	Damage to the radial nerve in the upper arm
Usually first presentation in childhood with a prominent shoulder topography, hypoplastic craniofacial bones, and progenia	None	Shoulders can be folded across his chest downward	None	None	Dysostosis cleidocranialis

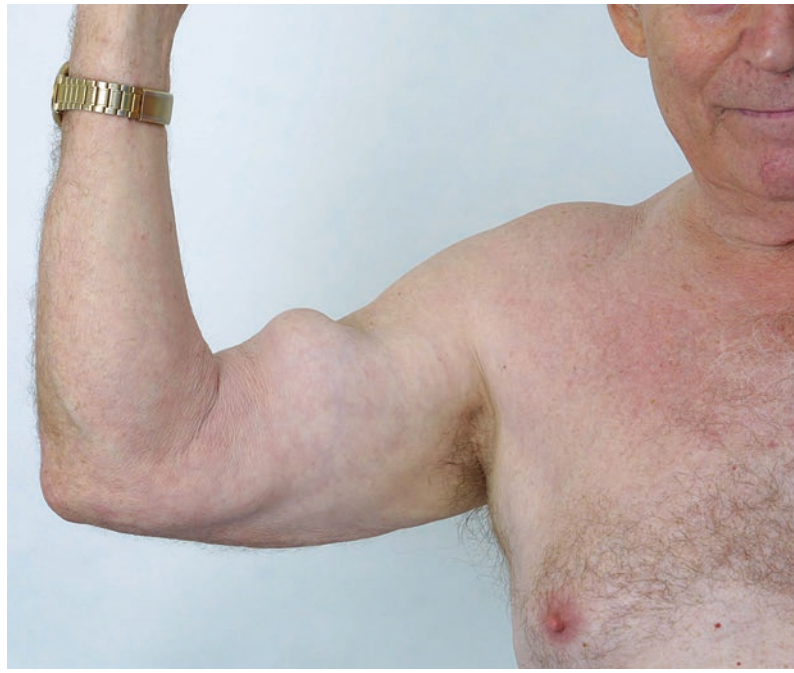


Fig. 2.2 Ruptured biceps tendon (long tendon): by actively flexing the arm in the elbow against the examiner's resistance, the muscle belly of the biceps muscle is distally displaced

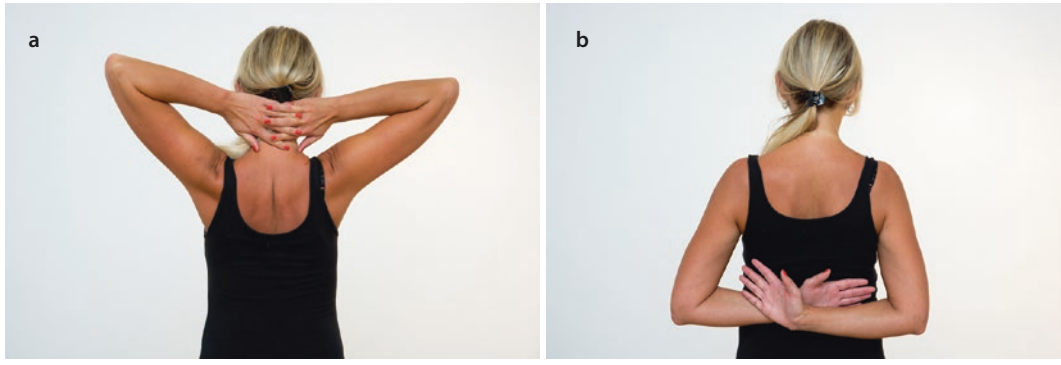


Fig. 2.3 (**a**, **b**) Shoulder function can be tested by asking the patient to hold onto his/her neck or by acting as if they are binding an apron behind their back. These are combined movements. Holding onto the neck tests abduction and external rotation. If abduction is intact, the elbow is held above the head. If abduction is limited, the elbow is often only held below the head. Binding an apron tests retroversion and internal rotation

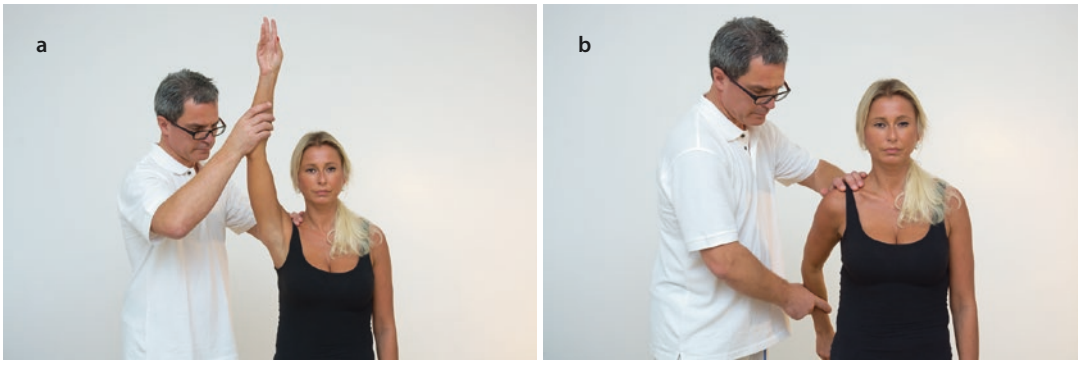


Fig. 2.4 To prevent the scapula from also moving, the shoulder is fixed when testing range of motion. For this, abduction/adduction, anteversion/retroversion, and internal/external rotation of the shoulder are performed. The movement can be performed either actively by the patient or passively by the examiner. When testing anteversion/retroversion in the shoulder (**a**, **b**), normal range of motion is 150–170/0/40°

Fig. 2.5 (**a**, **b**) Testing abduction/adduction in the shoulder joint (**a**, **b**) Range of motion: 90/0/40°. Some examiners include abduction beyond 90° with movement of the scapula and simultaneous external rotation of the arm (normal ROM for abduction up to 180°)

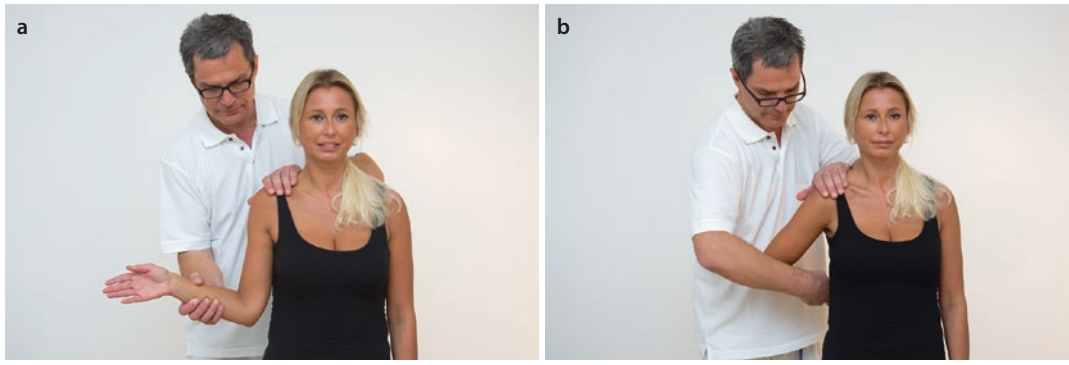


Fig. 2.6 (**a**, **b**) Testing external and internal rotation of the shoulder joint from the neutral position (**a**, **b**). Some examiners additionally examine rotation from a starting position of 90° abduction

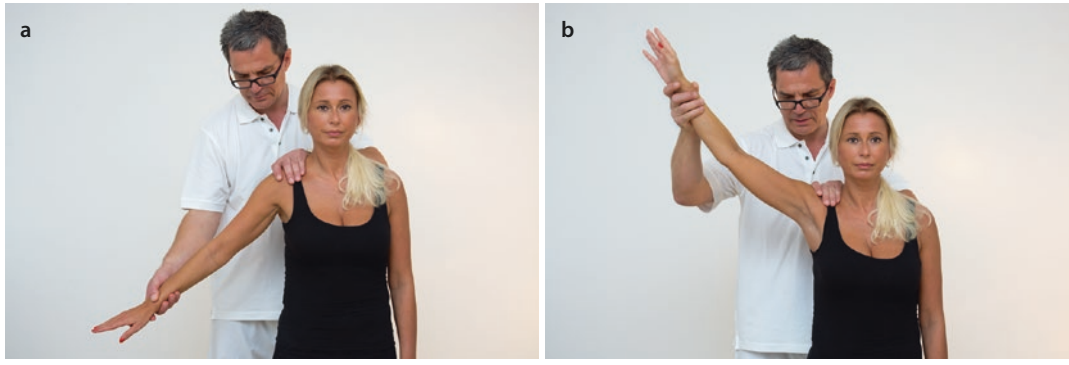


Fig. 2.7 Testing the painful arc in the shoulder: to determine subacromial stenosis, especially in cases of a supraspinatus tendon rupture, as well as a rotator cuff tear, the arm is abducted. The test is positive when during active abduction or adduction; pain is elicited between 40° (**a**) and 120° (**b**). Pain should decrease beyond 120° abduction, because the major tubercle has then exited the acromial roof. If pain is reported beyond 120° abduction, and further abduction exacerbates the pain, it is a strong indication for damage to the acromioclavicular joint

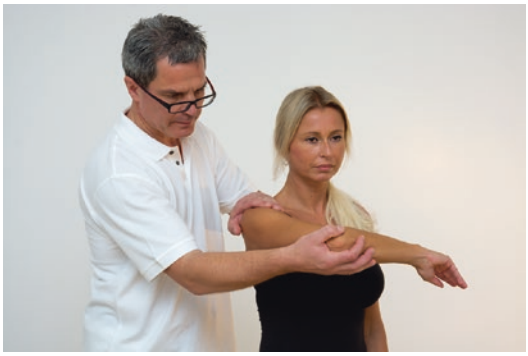


Fig. 2.8 Neer's impingement test: this test examines painful subacromial stenosis. The examiner fixes the scapula with one hand, while the other arm is used to elevate, adduct, and internally rotate the patient's arm. This causes the major tubercle to come in contact with the acromion. If subacromial inflammation is present, the test is painful

Fig. 2.9 Jobe test: this test examines shoulder function and impingement of the supraspinatus tendon. The patient holds the arm in 90° abduction and 30° anteversion. The elbow is stretched. The arm is internally rotated and the thumb points to the floor. Now the patient is asked to further abduct the arm in the shoulder against the examiner's resistance. If pain is elicited and muscle weakness is present when compared to the opposite side, the test is positive and indicates a lesion of the posterosuperior part of the supraspinatus tendon. If the test is painful in external rotation, this indicates a lesion to the anterior parts of the supraspinatus tendon

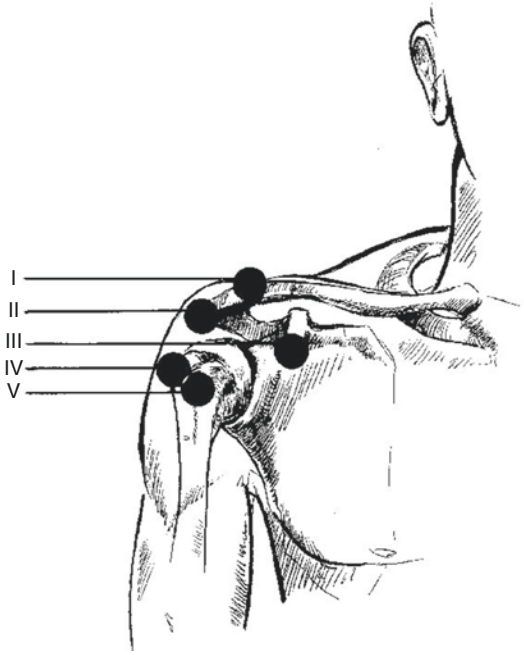


Fig. 2.10 Testing for tenderness at the shoulder joint: acromioclavicular joint (I), subacromial (II), coracoid process (III), major tubercle (IV), intertubercular sulcus (V)

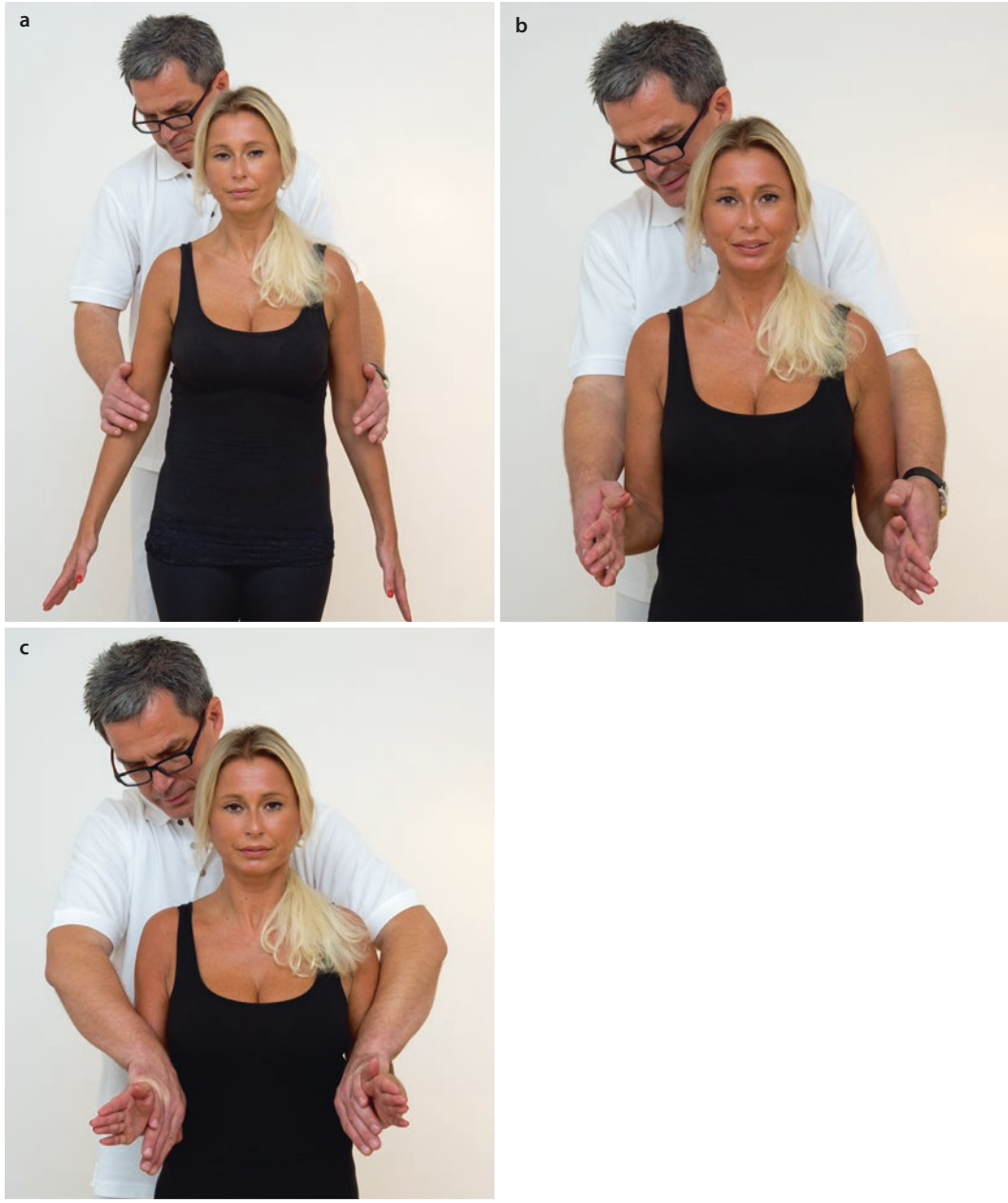


Fig. 2.11 (**a**, **b**, **c**) Testing active movement against resistance: pain is possible under abduction (**a**), external rotation (**b**), and internal rotation (**c**). The supraspinatus muscle serves as the starter of the shoulder abduction from the neutral position. To test this, the patient is asked to abduct the arm from the neutral position, i.e., 0° abduction (**a**), against the examiner's resistance. If this is not possible or weaker than the opposite side, it is an indication for a supraspinatus tendon lesion. From 40° abduction onward, the deltoid muscle assists in abduction. Pain during external rotation against resistance (**b**) indicates a lesion of the external rotators (infraspinatus and teres minor muscles). With the arm pressed to the trunk and the elbow flexed to 90°, the external rotation in the shoulder is performed against resistance. To prevent assistance of the deltoid muscle, external rotation can be tested in a 90° abducted and 30° horizontally flexed shoulder. Pain during internal rotation against resistance (**c**) indicates a lesion of the internal rotators (subscapularis muscle, pectoralis major muscle—these muscles do not form part of the rotator cuff). With the arm fixed to the trunk and the elbow flexed to 90°, internal rotation in the shoulder against the examiner's resistance is tested. If pain is reported, this indicates a subscapularis lesion

Fig. 2.12 Yergason test: the patient flexes the elbow to 90° and pronates the lower arm. The patient attempts to supinate the arm and further flex the arm in the elbow against the examiner's resistance. The test is positive if pain is felt in the intertubercular sulcus (the long head of the biceps tendon)

Fig. 2.13 Palm-up test: the arm is lifted against resistance in 90° elevation with supination of the stretched elbow. The test is positive if pain is felt at the intertubercular sulcus

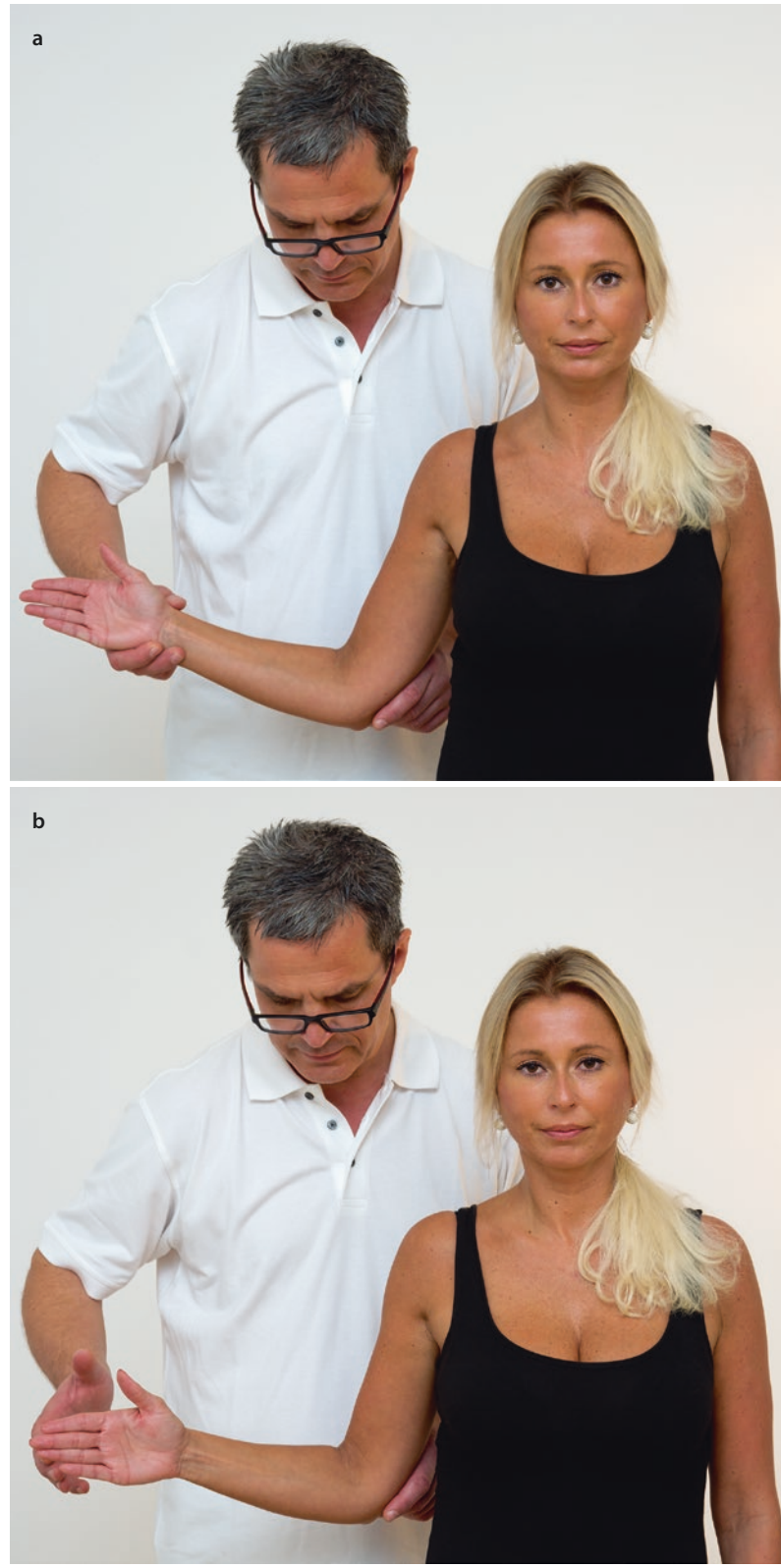


Fig. 2.14 (**a**, **b**) External rotation lag sign: the examiner maximally rotates the patient's shoulder in an external direction. The patient's arm is fixed to the trunk and flexed at the elbow. The patient is asked to hold this position (**a**). If the patient cannot hold the position, the external rotation lag sign is positive and indicates an infraspinatus or teres minor lesion. Once the examiner releases the patient's arm, the patient's arm spontaneously swings back inward (**b**) (in this example, this is simulated)

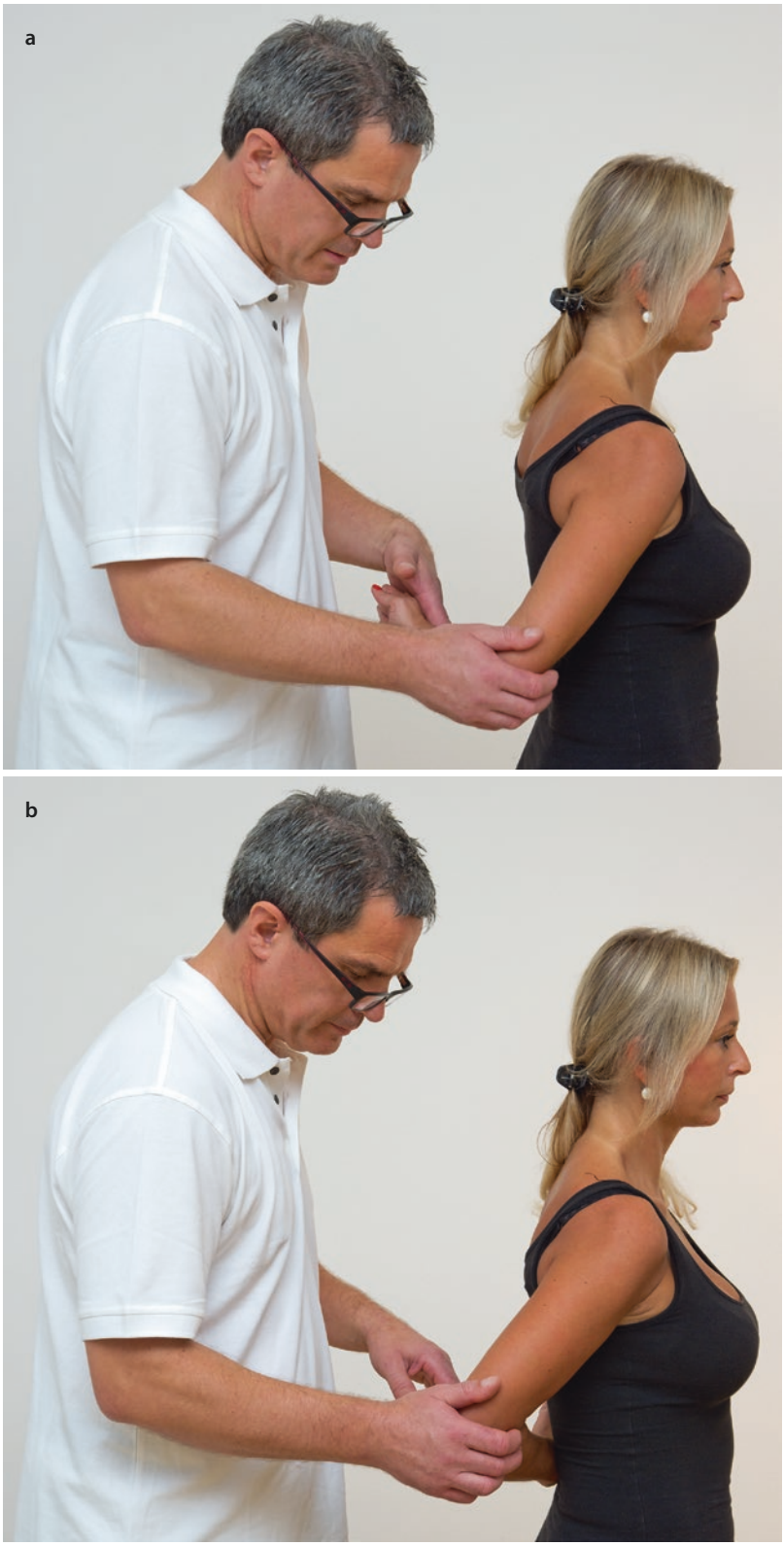


Fig. 2.15 (**a**, **b**) Internal rotation lag sign: the patient's hand is led behind his back and lifted to maximally internally rotate the shoulder. The patient is asked to hold this position (**a**). In cases of a subscapularis muscle lesion, releasing the patient's hand leads to a spontaneous return to the starting position (external rotation) and the hand moves down against the back (**b**) (simulated here)

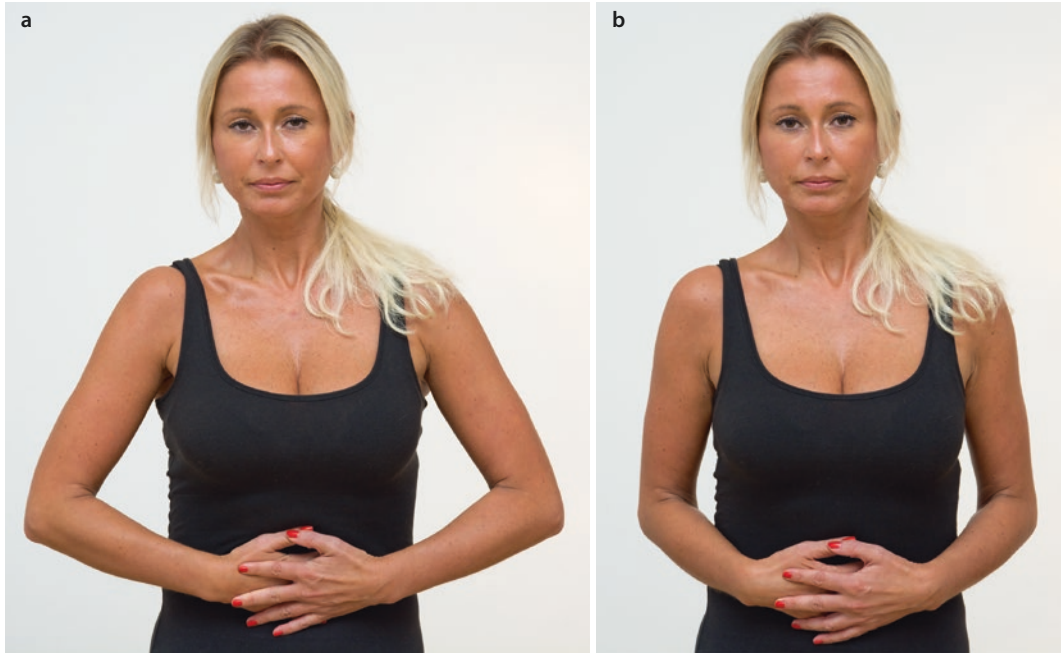


Fig. 2.16 Belly-press test (Napoleon sign): the patient presses the flexed lower arm against the abdomen and tries to hold the elbow at the same level (**a**). If the subscapularis tendon is ruptured, the elbow dorsally sinks down and the hand is flexed (**b**) (simulated here). Even if the test is inconspicuous, a subscapularis rupture is still possible

Fig. 2.17 Anterior apprehension test: following anterior shoulder dislocation, anterior shoulder instability can occur. The examiner abducts the arm to 90°, flexes the arm in the elbow, and rotates the arm externally. Simultaneously, the examiner presses onto the humerus head from behind. In cases of anterior instability, this causes muscular resistance. The patient reports pain and fear that the shoulder may dislocate

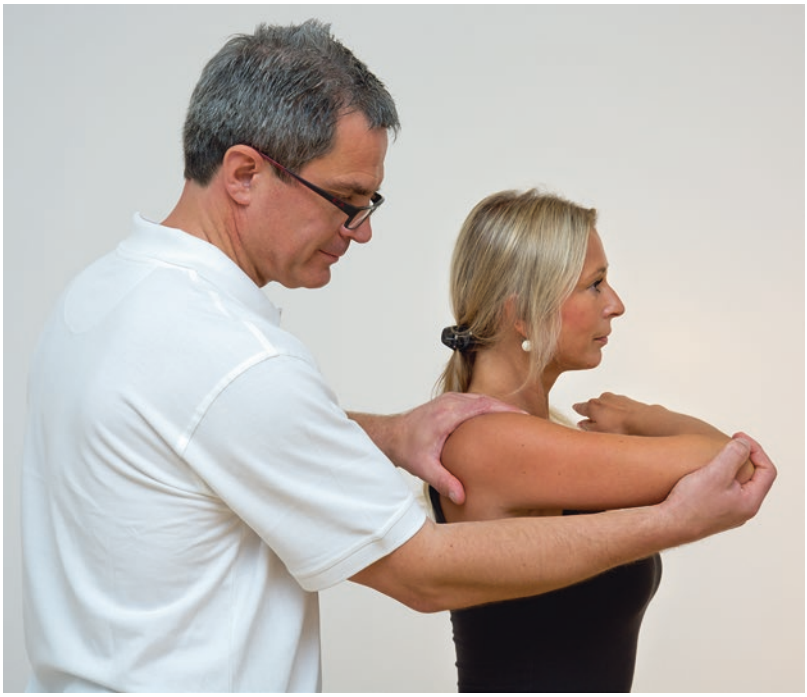


Fig. 2.18 Posterior apprehension test: posterior shoulder stability can be tested by applying pressure to the humerus in a dorsal direction with the shoulder in 90° anteversion. Reporting pain and a dislocation tendency indicate posterior shoulder instability. The posterior apprehension test is positive

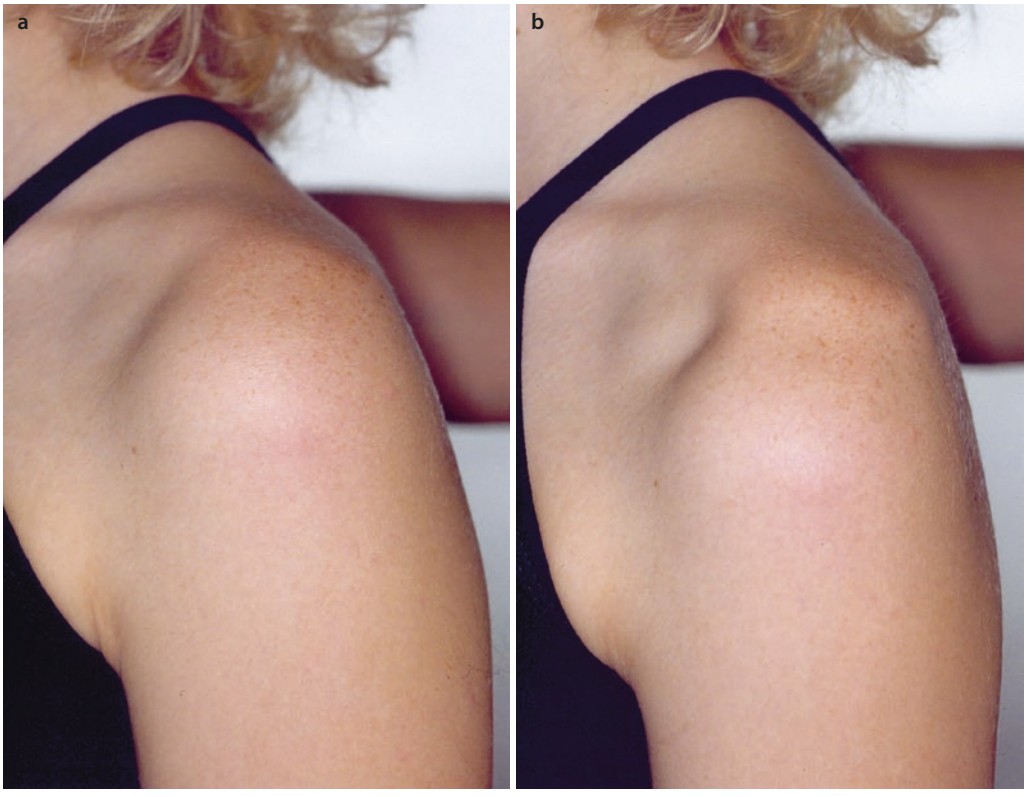


Fig. 2.19 Sulcus sign: the examiner pulls the patients hanging arm down. If inferior instability exists, a dimple is visible under the lateral acromion (**a**, **b**)

Fig. 2.20 Horizontal adduction test (cross-body test): in shoulder pathologies (e.g., arthrosis), pain in the shoulder can be provoked by adduction of the arm that is held in 90° anteversion

Fig. 2.21 Finger spreading test: the patient is asked where the pain is located. If pain is present in the shoulder, the patient will report a specific site and point his finger to the shoulder (positive finger pointing test)

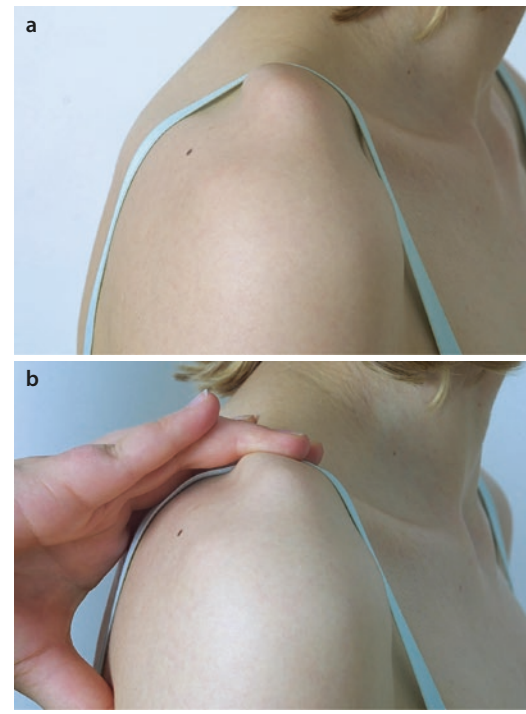


Fig. 2.22 (**a**, **b**) Piano key phenomenon: in clavicular instability, the clavicle can be pressed down like a piano key

Fig. 2.23 Testing the anterior–posterior mobility of the clavicle in the acromioclavicular joint

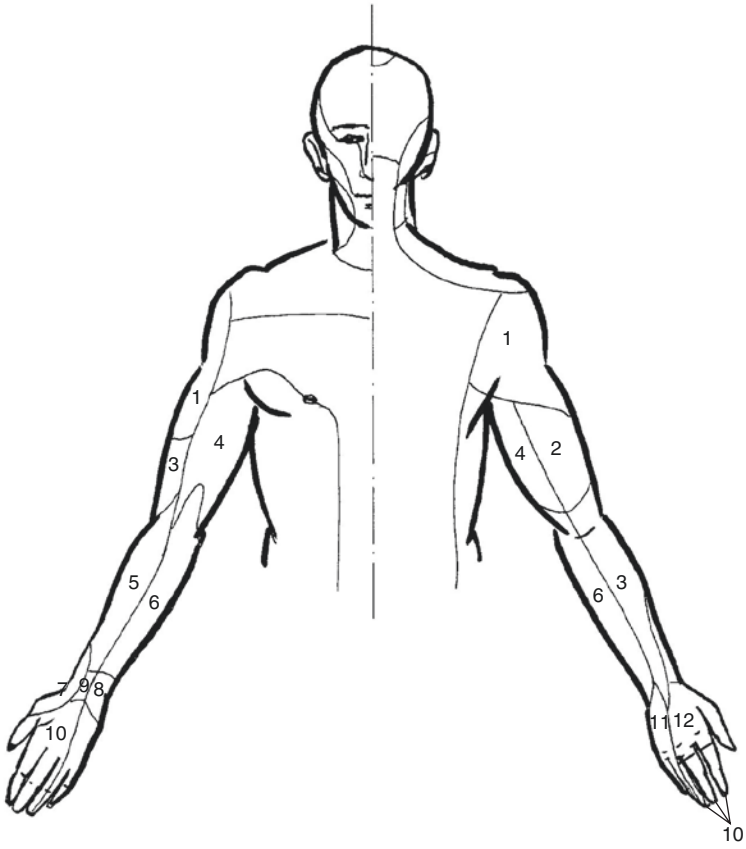


Fig. 2.24 Peripheral sensory innervation at the trunk and the upper extremity (anterior and posterior view). 1 N. cutaneus brachii lateralis (N. axillaris); 2 N. cutaneus brachii posterior (N. radialis); 3 N. cutaeus antebrachii posterior (N. radialis); 4 N. cutaneous brachii medialis; 5 N. cutaneus antebrachii lateralis (N. musculocutaneus); 6 N. cutaneus antebrachii medialis (Plexus brachialis); 7 Ramus superficialis n. radialis; 8 Ramus superficialis n. ulnaris; 9 R. palmaris n. mediani; 10 N. medianus; 11 N. ulnaris; 12 N. radialis

2.2.3 Disorders

- **Common clinical disorders**

Habitual Dislocation of the Shoulder

Glenohumeral instability that is accompanied by recurring atraumatic dislocations of the shoulder. One distinguishes among anterior, inferior (most common), and posterior dislocation. The inferior dislocation is often accompanied by an anterior or posterior dislocation. Dislocation in one direction is known as unidirectional; dislocations in multiple directions are known as multidirectional. Dislocations are often preceded by subluxations. One also distinguishes between random and paralytic dislocations.

- *Etiology*: atraumatic origin (no history of accident). Generalized capsule and ligament laxity. Congenital malformations of the humeral head, joint cup, and the ligaments. Paralytic dislocations occur in the context of shoulder muscle paralysis.
- *History*: habitual dislocation of the shoulder is almost always mentioned when taking patient history. Often, the patient already has a history of subluxations since childhood. Often, subluxations are not noticed. Also, dislocations and subluxations in adolescence and early adulthood during sport are common. The dislocation can mostly be easily repositioned. Both shoulders can be affected. Recurrent dislocation is common. Random dislocations often present in childhood (then mostly posterior). Psychological aspects are often important to consider.
- *Examination*: patients mostly present with non-dislocated shoulders ◘ Fig. 2.1. A lateral indentation in the shoulder and a guarding posture can be difficult to spot. Depending on the dislocation direction, the stability test can be positive (anterior shoulder apprehension test, ◘ Fig. 2.17; sulcus sign, ◘ Fig. 2.19; positive posterior apprehension test, ◘ Fig. 2.18). A palpable snapping of the tissue can occur. Often the joints show hypermobility.
- *Diagnostics*: X-ray of the shoulder in two planes and special targeted imaging (looking specifically at the bones), CT (with angiography), MRI, ultrasound (muscles, ligaments, labrum).
- *DD*: to be clearly differentiated from traumatic and post-traumatic recurrent shoulder dislocation.

Neuralgic Shoulder Amyotrophy

Acute, intense shoulder pain in the shoulder–arm region. Motor and sensory function loss manifests themselves as a consequence, especially in the upper arm plexus (C5/6).

- *Etiology*: unknown.
- *History*: sudden intense pain in the shoulder that radiates into the arm, mostly with a diffuse character. After a few days, the arm hangs flaccid and inwardly rotated. Paralysis is followed by muscular atrophy.
- *Examination*: no movement limitation in the cervical spine! Shoulder abduction is completely paralytic (◘ Fig. 2.5) as well as external rotation (◘ Fig. 2.6). Scapula alata is common (◘ Fig. 1.24). Sensory loss over the deltoid muscle and the radial under arm is rare (◘ Fig. 1.11).
- *Diagnostics*: X-ray of the cervical spine in two planes and semi-oblique (to rule out degenerative alterations, bone destruction); X-ray of the shoulder in two planes. Neurological consultation.
- *DD*: radicular cervical compression syndrome; carpal tunnel syndrome, ulnar nerve compression, impingement syndrome, backpack paresis.

Scapula Alata ("Winged Scapula")

Unilateral elevation of the scapula from the chest wall.

- *Etiology*: long thoracic nerve injury and the resulting weakness of the anterior serrated muscles. Mostly idiopathic. Also possibly elicited by pressure injury ("backpack paresis") or trauma. Rarely leads to complete paralysis. Perioperative positioning damage or during casting is also possible. Neuralgic shoulder amyotrophy, inflammation, and progressive muscular atrophy should also be considered.
- *History*: "winging" of the scapula, often primarily a cosmetic concern (in neuralgic shoulder amyotrophy also a history of acute-onset shoulder pain).
- *Examination*: when the hands are supported and pressed against the wall or when doing a push-up, the tendency of the scapula to flare out becomes visible immediately (◘ Fig. 1.24).
- *Diagnostics*: X-ray of the shoulder in two planes (rule out pathological changes to the bone).
- *DD*: Sprengel deformity, exostosis, paresis of the accessory nerve (in this case, the scapula is lateralized and the shoulder is tilted), progressive muscular dystrophy (fascioscapular type), neuralgic shoulder amyotrophy (plexus neuritis).

Snapping Scapula Syndrome (Scapulocostal Syndrome)

Snapping sensation during movement of the scapula.

- *Etiology*: incorrect posture, tense muscles, bursitis, costal hump in scoliosis, form alteration of the scapula (callus, exostosis), tumors.
- *History*: snapping sensation behind the scapula. Can also be consciously elicited.
- *Examination*: palpation of the scapula with the hand. When the scapula is moved, the "snapping" can be palpated, sometimes also heard. Tenderness to pressure and increased muscle tone over the medial scapular ridge.
- *Diagnostics*: X-ray of the shoulder in two planes (to rule out pathological changes to the bone).
- *DD*: all etiologically relevant disorders.

Subscapularis Tendinitis

Degenerative alteration of the of the subscapular muscle tendon, its gliding surface, and its insertion site.

- *Etiology*: multifactorial. Nutritional problems, paradox arterial ischemia in athletes caused by heightened metabolism under stress (e.g., rigorous exercise program); degenerative.
- *History*: mostly young patients. Pain elicited by sudden tension in stretched muscles (tennis, javelin). Also seen as load-induced pain in women between 40 and 60.
- *Examination*: tenderness over the minor tuberculum. Positive painful arc, positive Jobe test, and positive Neer's impingement test (Figs. 2.7, 2.8, and 2.9). Pain at inward rotation against resistance (Fig. 2.11).
- *Diagnostics*: X-ray imaging of the shoulder in two planes (to rule out pathological bony alterations); ultrasound (rule out rotatory cuff rupture and biceps injury).
- *DD*: primary and secondary impingement syndrome.

Primary Frozen Shoulder

Reversible stiffness of the shoulder joint occurring in three characteristic phases. Accompanied by a transient shrinking of the capsule, which subsides in the late stadia of the disorder. The duration of the stadia is between 4 and 6 months, the whole course of disease between 12 and 18 months. Less common than the secondary frozen shoulder.

- *Etiology*: not fully known. A local immune reaction with a genetic predisposition is being discussed. Often patients present with a history of cervical syndrome, myocardial infarction, mastectomy, hemiplegia, Pancoast tumor, and medication (barbiturates).
- *History*: commonly presents between 40 and 60 years of age, especially in women. Often affects the nondominant arm.
  Stage 1 (*painful phase*): increasing pain, especially at night and when working with the arms over the head. Lying on the affected shoulder is not possible. Almost unnoticed, mild functional disorder.
  Stage 2 (*stiffening phase*): subsiding pain (only present during sudden movement). Increasing stiffness of the shoulder. Clear functional impairment in everyday use and in work.
  Stage 3 (*thawing phase*): further subsiding of pain. Without special treatment, movement function is slowly restored.
- *Examination*:
  Stage 1 (*painful phase*): movement is initially not impaired and pain is only felt in some movements.
  Stage 2 (*stiffening phase*): clear muscular atrophy. Abduction is only possible with outer rotation of the scapula. Pain at the end of a movement during passive testing of impaired mobility.
  Stage 3 (*thawing phase*): mobility returns to an almost physiological condition (Figs. 2.4, 2.5, and 2.6).
- *Diagnostics*: X-ray of the shoulder in two planes (to rule out pathological changes to bone, tendinitis calcarea), ultrasound (to rule out subacromial bursitis); arthrography (to prove capsule shrinkage).
- *DD*: secondary frozen shoulder, trauma, and upper arm plexus paresis.

Secondary Frozen Shoulder

Painful movement impairment of the shoulder due to an external cause or a different disorder of the shoulder. In contrast to primary frozen shoulder, the shrinkage of the capsule plays a minimal role. Much more common than primary frozen shoulder.

- *Etiology*: primary and secondary impingement syndrome (rotator cuff lesion, calcific tendinitis of the shoulder, biceps lesions). Degenerative and inflammatory disease of the shoulder as well as cervically or abdominally radiating pain, fractures, and dislocation.

- *History*: pain-relieving posture of the arm, leading to a limitation of external rotation (Fig. 2.6) and abduction (Fig. 2.5). During these movements (e.g., when combing one's hair), the shoulder is typically elevated. Pain and movement impairment do not occur in the form of phases.
- *Examination*: depending on the primary location of injury, local tenderness can present, e.g., subacromially, at the major or minor tubercle or over the sulcus intertubercularis. Movement, especially abduction (Fig. 2.5) and outer rotation (Fig. 2.6), is impaired (Fig. 2.3).
- *Diagnostics*: X-ray of the shoulder in two planes (to rule out pathological changes to the bone), ultrasound, and eventually CT and MRI scans to show pathological changes in the rotatory cuff, biceps tendon, and the subacromial bursa.
- *DD*: all etiologically relevant disorders. Primary frozen shoulder.

Pseudoarthrosis of the Clavicle (Acquired)

Nonunion of the bones involved in the clavicular joints.

- *Etiology*: insufficient reposition or fixation during conservative treatment of a clavicular fracture (rare) or insufficient operative stabilization (e.g., with K-wires—common).
- *History*: pseudoarthrosis should be considered if pain exists after more than 8 weeks following a clavicle fracture. Pain is elicited by load and at rest. Weakness and paresthesia are present. Blood perfusion problems are possible.
- *Examination*: alterations to the surface are possible, localized tenderness, differing levels or protrusions are palpable. Abnormal mobility is possible with eventually a positive Adson test (Fig. 1.13). Piano key phenomenon possible (Fig. 2.22).
- *Diagnostics*: X-ray of the clavicle a.p. (to prove pseudoarthrosis).
- *DD*: costoclavicular syndrome.

Sternoclavicular Hyperostosis

Stiffening of the sternoclavicular joint due to ossification of the sternoclavicular ligaments and bone formation between the sternum, the clavicle, and the first rib.

- *Etiology*: unknown.
- *History*: mostly bilateral in patients between the ages of 30 and 50 years. Pain in the acromioclavicular joint.
- *Examination*: local swelling and protrusion of the medial clavicular margin. Later local tenderness at the acromioclavicular joint.
- *Diagnostics*: X-ray of the clavicle a. p. (to visualize the bony configuration of the clavicle).
- *DD*: Tietze syndrome, sternoclavicular arthritis, sternoclavicular subluxation.

Impingement Syndrome (Supraspinatus Tendonitis)

Painful function impairment of the shoulder caused by contact in the subacromial soft tissue at the anterior ridge of the shoulder and/or the acromion, especially when spreading the arms. The lesions caused by this impingement can involve the rotator cuff, the subacromial bursa, and the long biceps tendon.

Primary impingement (*outlet impingement*): *mechanical constriction around the joint surface of the supraspinatus tendon between the acromioclavicular joint, the anterior acromion, the coracoacromial tendon, and the coracoid process* (*so-called supraspinatus outlet*).

Secondary impingement (non-outlet impingement): functional contraction of the subacromial space. Subacromial conflict situation caused by volume increase of the subacromial soft tissue and a high-riding shoulder (superior displacement of the humerus).

- *Etiology*:
  Primary impingement: congenital form alteration of the anterior third of the acromion, caudal osteophytes at the acromioclavicular joint, and post-traumatic positional changes to the coracoid process.
  Secondary impingement: chronic subacromial bursitis, tendinitis calcarea, rotator cuff tear or the long biceps tendon, glenohumeral instability (habitual and traumatic shoulder dislocation), frozen shoulder, pseudoarthrosis of the major tubercle, and prostheses that are too deeply implanted.
- *History*:
  Primary impingement:
  Stage I (edema and hemorrhage): pain during overhead work, mostly affects active patients under 25 years of age. Symptoms are reversible.
  Stage II (fibrosis and tendonitis): pain after strain to the joint, typically at the outer

part of the proximal upper arm. Typically occurs from age 25–40. Symptoms are mostly reversible.

Stage III (rotator cuff tear): movement-dependent chronic shoulder pain, nocturnal pain at rest, and pseudoparalysis. Symptoms are not reversible. The stages are not always easy to differentiate. It is important to rule out other causes of shoulder pain.

Secondary impingement: shoulder pain, functional disorders, age, and course are determined by the cause of the pain.

- *Examination*:

  Primary impingement: tenderness to pressure at the major tubercle and the minor tubercle, the intertubercular sulcus, the subacromial, and the coracoid process (Fig. 2.10). Active elevation is more painful than passive elevation. Positive Neer's impingement test (Fig. 2.8). Crepitation. Positive painful arc (Fig. 2.7). Abduction against resistance painful (supraspinatus muscle) (Fig. 2.11). Positive Jobe test (Fig. 2.9). Also possible, painful external rotation against resistance (infraspinatus muscle) (Fig. 2.11). Alleviation is experienced in the subacromial local anesthesia test. Weakness in abduction and rotation against resistance if the rotatory cuff is torn. Active and passive movement limitations are possible.

  Secondary impingement: dependent on the differential diagnoses (chronic subacromial bursitis, tendinitis calcarea, rotator cuff tear, biceps tendon rupture, glenohumeral instability (habitual and traumatic shoulder dislocation), and frozen shoulder).

It is important to distinguish between primary and secondary impingement as this influences therapy. Primary impingement calls for conservative or surgical treatment, in some cases, requiring reconstruction of the rotator cuff. In secondary impingement, the cause for the impingement needs to be removed; otherwise, symptoms grow worse.

- *Diagnostics*: X-ray of the shoulder in two planes (to visualize the bones and rule out other causes).

■ *Bursitis Subacromialis*

No independent disorder. Accompanies the chronic or acute stage of tendinitis calcarea as well as chronic polyarthritis and other disorders of the shoulder.

■ *Tendinitis Calcarea (Calcifying Tendinitis)*

Non-degenerative disorder with focal calcific deposits in the tendons of the rotator cuff. This is initially accompanied by decreased perfusion and cell-induced "chalky" calcific deposits in the inner tendon. The calcification can gradually increase. The calcification mostly resolves within some days under acute pain (*acute stage*).

- *Etiology*: unknown, but certainly not degenerative.
- *History*: Mostly affects middle-aged women. In the *latent stage* mostly clinically inconspicuous. In the *chronic stage*, chronic to acute pain.

  Acute stage: strong pain at day and at night, painful reduction in range of motion continuing for some days.

  Repair stage: decreasing pain; relapses are possible.
- *Examination*: In the *chronic stage*, localized pain to pressure over the calcific deposit at the proximal upper arm. Reduction in range of motion is possible (Figs. 2.3, 2.4, 2.5, and 2.6). Positive Jobe test (Fig. 2.9). Positive Neer's impingement test (Fig. 2.8).

  Acute stage: Shoulder often slightly swollen and warm, tenderness to pressure! Active and passive movement painfully limited.

  Repair stage: Receding tenderness, return to normal range of motion.
- *Diagnostics*: X-ray of the shoulder in two planes, ultrasound (to visualize the calcific deposit; to rule out other causes).
- *DD*: secondary impingement. In the acute stage: purulent omarthritis, arthritis urica of the shoulder, and pseudogout.

- **Congenital malformation and metabolic disorders**

■ *Sprengel Deformity (Congenital High Scapula)*

Congenital high sitting scapula accompanied by a craniomedial displacement and external rotation of the scapula. Often combined with a decrease in size and a coarsening of the scapula.

- *Etiology*: congenital, most likely a genetic etiology. Eventually also an exogenous etiology (embryopathy).
- *History*: mostly only affects one side. More common in women than men. Mostly manifests in combination with other deformities (scoliosis, anomalies of the ribs, Klippel–Feil

syndrome, spina bifida). Shortening of the levator scapulae muscle. High-standing shoulder blade.
- *Examination*: the high-standing scapula is conspicuous when inspecting the patient from the back. If accompanied by Klippel–Feil syndrome, this impression is further emphasized by the webbed neck (pterygium colli). Range of motion is often not affected in the shoulder joint but limited at the scapulothoracic joint.
- *Diagnostics*: X-ray of the scapula anterior–posterior and the cervical spine in two planes (to show high-standing scapula and rule out associated disorders of the cervical spine).

■ *Cleidocranial Dysostosis*

Rare. Systemic disorder involving delayed ossification leading to hypoplasia and aplasia especially of the skull and the clavicle.
- *Etiology*: *congenital*, *autosomal dominant*.
- *History*: the dominating clinical picture is the one-sided (mostly right-sided) or bilateral, partial, or total aplasia of the clavicles. A combined defect with shortening of the base of the skull, a hypoplasia of the facial skull, hypoplasia of the maxilla leading to prognathism, as well as aplasia of the symphysis and coxa vara is also possible.
- *Examination*: in total aplasia, the shoulders can touch each other at the chest. In partial aplasia, a hypermobility of the shoulders exists.
- *Diagnostics*: none.
- *DD*: pycnodysostosis (or in combination with osteopetrosis, the so-called marble bone disease)

■ *Gouty Arthritis of the Shoulder*

Very rare in the shoulder! *Inflammatory alterations of the shoulder joint*, *characterized by deposits of uric acid crystals in the shoulder joint and in the periarticular soft tissue. Manifests as acute arthritis or chronic arthropathy. The acute gout attack of the shoulder is known as omagra.*
- *Etiology*:
  Primary: purine metabolism disorder caused by a genetic defect, involving reduced renal excretion of uric acid or increased synthesis. Mostly induced by overeating.
  Secondary gout is seen in hematological disorders involving cell destruction or disorders involving renal function impairment.
- *History*: presents in flares. Gout is similar to infectious arthritis during an attack, presenting with redness, swelling, loss of function, and severe pain. Mostly lasts days to weeks. After an acute attack, the symptom-free intervals tend to become shorter (in case of no treatment).
- *Examination*: during a flare-up, massive swelling, redness, hyperthermia, protective stance, tenderness, and pain upon movement.
- *Diagnostics*: X-ray of the shoulder in two planes (to rule out bony destruction, tendinitis calcarea). Blood tests: leukocytosis, slightly elevated erythrocyte sedimentation rate (ESR), elevated uric acid levels in plasma (hyperuricemia).
- *DD*: omarthritis (acute rheumatic, unspecific, and specifically infectious), pseudogout, tendinitis calcarea (acute stage).

■ *Pseudogout (Chondrocalcinosis)*

Arthritis of the shoulder joint, *caused by microcrystal deposits* (*calcium pyrophosphate crystals*). *The history and symptoms resemble gout. Chronic cases result in arthropathy.*
- *Etiology*: unknown. Metabolic disorder involving deposits of calcium pyrophosphate crystals in the synovial fluid and the joint capsule.
- *History*: mostly older patients. Similar to gout, yet with a milder course of disease.
- *Examination*: swelling, redness, hyperthermia, tenderness to pressure or movement.

Due to mild course of disease, *pseudogout is often misdiagnosed as an arthritic irritation during active arthrosis.*
- *Diagnostics*: X-ray of the shoulder in two planes (analyzing the bones and ruling out pathological changes.) Arthrocentesis (polarized light microscopy).
- *DD*: gout, rheumatoid arthritis, active arthrosis, infectious arthritis, specific omarthritis.

- **Degenerative disorders**

■ *Biceps Tendon Lesions*

This includes all degenerative changes and rare traumatic changes to the biceps tendon and its supporting structures. One distinguishes among tendinopathy, *tearing, and instability of the biceps tendon.*

Tendinopathy of the biceps tendon

Degenerative changes to the biceps tendon. Rarely an isolated disorder, *mostly occurs in combination with damage to the supraspinatus tendon and fibrosis of the subacromial bursa in the context of impingement syndrome* (*stage II*).

- *Etiology*: degenerative. Strong subacromial friction as a consequence of primary or secondary impingement and tearing of the rotatory cuff promote the development of degenerative changes to the tendon in the bicipital groove.
- *History*: long overhead activity, Swimming, tennis, and golf. Pain in the anterior shoulder area.
- *Examination*: localized tenderness to pressure in the bicipital groove (Fig. 2.10). Pain alleviation by means of an intertubercular local anesthesia test. Positive Yergason test (Fig. 2.12). Positive palm-up test (Fig. 2.13).
- *Diagnostics*: X-ray of the shoulder in two planes (to rule out changes to the bone) and ultrasound (examining the rotator cuff, the biceps tendon, the subacromial bursa).

Biceps tendon rupture

Degenerative or traumatic rupture of the long head of the biceps tendon. Often occurs in combination with rotator cuff tear and impingement syndrome (stage III). The long head of the biceps tendon forms a functional unit with the rotator cuff. A loss of function of the long head causes an elevation of the humeral head.

- *Etiology*: degenerative. Rarely traumatic.
- *History*: Very rarely seen following trauma in young patients (traumatic rupture). Mostly seen in older patients following minor trauma or sudden strong contraction (degenerative rupture). Sharp pain in the proximal upper arm. Often preceded by shoulder pain, in some cases slowly increasing pain (creeping rupture). A distal displacement of the muscle is seen, combined with muscle weakness (often less pronounced in older patients).
- *Examination*: localized hematoma (not always present), localized tenderness. During elbow flexion against resistance, the distal displacement of the muscle becomes visible (in contralateral comparison) (Fig. 2.2). In young patients, there is a clear reduction in strength during flexion; in older patients, this is often less pronounced.

Always look for associated injury to the rotatory cuff!

- *Diagnostics*: X-ray of the shoulder in two planes (to rule out degenerative or destructive changes). Ultrasound (examining the rotatory cuff, the biceps tendon, the subacromial bursa).
- *DD*: instability of the long head of the biceps tendon.

Instability of the long head of the biceps tendon

This disorder involves subluxation and dislocation.

- *Etiology*: degenerative. Occurs in the context of rotatory cuff tearing that damages the coracohumeral ligament; also promoted by a preexisting flat bicipital groove.
- *History*: pain in the anterior shoulder area. Snapping of the tendon. Overlap with symptoms of rotatory cuff tear is common.
- *Examination*: localized tenderness in the bicipital groove (Fig. 2.10), positive Yergason test (Fig. 2.12), palpable tendon at abduction and outer rotation. Positive tests during rotator cuff rupture.

Often a large defect in the anterior rotator cuff is also present.

- *Diagnostics*: X-ray of the shoulder in two planes (to rule out degenerative or destructive changes), ultrasound (examining the rotator cuff, the biceps tendon, the subacromial bursa).
- *DD*: biceps tendon rupture.

■ Rotator Cuff Tear

Partial or complete tear of the tendons of the rotator muscles. Often occurs in combination with lesions of the long head of the biceps tendon.

- *Etiology*: mostly degenerative changes, often creeping without any history of trauma. If there are preexisting degenerative changes, trauma can be the causal factor. Purely traumatic lesions are rare. They only occur in cases of severe trauma such as falling onto extended arms. In very rare cases of shoulder dislocation, an accompanying traumatic rupture occurs between the tendons of the supraspinatus muscle and the subscapularis muscle.
- *History*: degenerative tears commonly occur after the age of 40. They can be induced by falling or sudden lifting of a heavy object (50 %). Initially a sudden severe pain is felt, followed by a loss of active mobility; a subcutaneous hematoma can also be seen after some days. Often no causal factor can be determined: in these cases, creeping pain, initially especially nocturnal pain, then also during the day is felt.

If trauma (mostly in patients under 40) and interval tearing (older patients) are involved, acute shoulder pain is mostly present as well as a loss of function of the shoulder. In case of larger rupturing, a complete loss of function in the shoulder can occur.

- *Examination*: fresh ruptures may present with hematoma, subacromial tenderness, and tenderness at the major tubercle and the coracoid process (Fig. 2.10). Palpable snapping and subacromial crepitation are possible, as well as a positive painful arc (Fig. 2.7) and positive drop arm test (the examiner performs a passive abduction of the patient's arms and asks the patient to slowly adduct both arms; the test is positive when the arm cannot be slowly adducted but falls down). The passive mobility is normal; the active mobility is limited (Figs. 2.3, 2.4, 2.5, 2.6, and 2.7). Testing mobility against resistance induces pain and weak abduction (supraspinatus muscle) and/or abduction weakness (supraspinatus muscle), internal rotator weakness (subscapular muscle), and external rotator weakness (infraspinatus muscle, teres minor muscle) (Fig. 2.11). Furthermore, a positive internal rotation lag sign, external rotation lag sign, or Belly-press test (Fig. 2.16) may be seen (Figs. 2.14, 2.15, and 2.16). In cases with severe rupturing, the arm cannot be actively raised anymore (pseudoparalysis).
- In older findings, secondary impairment of passive mobility (secondary frozen shoulder) and atrophy of the supraspinatus and infraspinatus muscles may be found.
- *Diagnostics*: X-ray of the shoulder in two planes (to rule out bony alterations, shoulder elevation), ultrasound, (athropneumo) CT, and MRI (to visualize rotator cuff tear).

Acromioclavicular Arthrosis

Degenerative disorder of the acromioclavicular joint. Also seen in combination with rotator cuff tear.

- *Etiology*: in old age, the primary form dominates. In younger patients, arthrosis is mostly post-traumatic, especially following fracture of the lateral clavicle with subsequent remaining instability. Also seen following infections.
- *History*: pain at the shoulder (not in the upper arm!) reaching up to the neck. The pain arises following excessive loading and is exacerbated by overhead work or sports. Can also be clinically symptom-free.
- *Examination*: localized tenderness to pressure at the acromioclavicular joint. Positive horizontal adduction test (Fig. 2.20). Positive finger pointing test (Fig. 2.21). Pain in the acromioclavicular joint is exacerbated by abduction beyond 120° (positive painful arc) as well as by adduction from a 90° anteversion position.
- *Diagnostics*: X-ray of the shoulder in two planes (to visualize the degenerative changes at the acromioclavicular joint).
- *DD*: rheumatoid arthritis, infectious arthritis.

Omarthrosis

In primary omarthrosis, beyond the typical morphological changes to the cartilage and bone, an enlargement of the humerus head sets in and in some cases an erosion of the posterior margin of the glenoid cavity leading to dorsal subluxation of the humeral head. Moreover, an enlargement of the posterior ligaments is seen. Secondary omarthrosis develops on the basis of preceding injury.

- *Etiology*: primary (cause unknown). Secondary after repositioned dorsal dislocation, preoperated instability, and in deformity or dislocation fractures that have not healed (more common). Also common in chronic polyarthritis, chondromatosis, and villonodular synovitis of the shoulder joint.
- *History*: pain under load with alleviation at rest. Weakness and impaired mobility. Primary omarthrosis mostly presents after 60, mostly bilateral (otherwise mostly on the right side) and commonly in women. Can also lead to impingement in cases of chondromatosis.
- *Examination*: atrophy of the shoulder muscles (supraspinatus, infraspinatus, deltoid), localized tenderness to pressure, pain during movement, grating sound, and crepitation. Active and passive mobility limited (especially external rotation and internal rotation (Figs. 2.4, 2.5, and 2.6)).
- *Diagnostics*: X-ray of the shoulder in two planes (proof of omarthrosis, ruling out humeral head arthrosis and chondromatosis). Ultrasound.
- *DD*: especially in the early stages, all etiologically relevant disorders, humeral head necrosis.

Rotator Cuff Arthropathy

Special form of omarthrosis. Late condition of a severe rotator cuff defect in combination with glenohumeral instability. Involves loss of cartilage, destruction of the subchondral plate, and arrosion at the acromion and at the acromioclavicular joint as well as at the coracoid process. Osteoporosis develops due to the severe immobility. The long head of the biceps tendon is mostly ruptured.

- *Etiology*: nutritious and mechanical factors.
- *History*: recurring subluxation. Increasing pain at rest and under load. Decreased muscle strength and mobility.
- *Examination*: atrophy of the shoulder muscles (supraspinatus, infraspinatus, deltoid muscles), localized tenderness to pressure, pain during movement, crepitation, grating noise. Reduced range of motion during passive movement. The arm cannot be actively lifted (pseudoparalysis).
- *Diagnostics*: X-ray of the shoulder in two planes (to visualize the damage at the joint), ultrasound (to visualize the rotator cuff rupture, to visualize the biceps tendon).
- *DD*: primary or secondary omarthrosis, osteonecrosis of the humeral head.

Osteonecrosis of the Humeral Head

Cellular death of bone tissue due to recurring or longer interruption of blood supply to the tissue. Often inconspicuous in the early stages, osteoporosis can develop in later stages. Can lead to fracturing and to complete destruction of the humeral head and a disturbed joint congruency.

- *Etiology*: traumatic (after fracturing and dislocation), alcohol abuse, steroids, infection, tumors, neuropathic (diabetes, syphilis, syringomyelia). Also aseptic bone necrosis in children.
- *History*: pain during loading, in later stages, pain at rest. In neuropathic cases, pain is absent. Mobility decreased.
- *Examination*: localized tenderness to pressure, pain during movement, impaired mobility.
- *Diagnostics*: X-ray of the shoulder in two planes (examining the damage, to rule out omarthrosis), ultrasound (examining the rotator cuff and the biceps tendon), scintigraphy (showing a pathological metabolism in the humeral head).
- *DD*: primary and secondary omarthrosis.

Inflammatory disorders

Nonspecific Inflammation

Purulent omarthritis (*infectious arthritis*)

Joint infection of the shoulder caused by microorganisms. The pathogen can be isolated from material in the joint. Mostly presents as monoarthritis. Also called septic arthritis.

- *Etiology*:
  Primary arthritis: infection via an open wound during surgery or during intra-articular injection. Secondary arthritis: hematogenous infection. In adults, mostly caused by staphylococcal, streptococcal, or *Neisseria* infection. In children, mostly caused by *Haemophilus influenzae*. Fungal infections are also possible. Patients more prone to infection include patients with a history of diabetes, alcohol abuse, tumors, HIV infection, and immunosuppressive therapy.
- *History*: severe swelling of the shoulder and a severe functional impairment. Severe pain and fever.
- *Examination*: swelling, redness, hyperthermia. Guarding. Tenderness to touch and pressure. In rheumatoid arthritis and immunosuppressive therapy, the physical findings can be less pronounced.
- *Diagnostics*: X-ray of the shoulder in two planes (to rule out bone destruction), ultrasound (effusion), scintigraphy, blood tests (blood sedimentation rate, leukocytes, CRP elevated), and puncture.
- *DD*: rheumatic omarthritis, active omarthrosis, gout, pseudogout, specific omarthritis.

Nonspecific sternoclavicular arthritis

Nonspecific chronic inflammation of the sternoclavicular joint without being able to isolate a pathogen.

- *Etiology*: unknown. Especially common in women of middle age and postmenopausal (postmenopausal arthritis).
- *History*: pain-free swelling of the sternoclavicular joint.
- *Examination*: local swelling of the sternoclavicular joint. No redness, no hyperthermia, no tenderness to pressure.
- *Diagnostics*: X-ray of the clavicle a.p. (to rule out any bony alterations). Ultrasound (soft tissue swelling), scintigraphy (increased accumulation of a tracer), blood tests (erythrocyte sedimentation rate, leukocytes, CRP slightly

elevated), and arthropuncture can also be performed.
- *DD*: Tietze syndrome, septic arthritis, arthritis in psoriasis, sternoclavicular hyperostosis, sternoclavicular subluxation.

Septic sternoclavicular arthritis

Bacterial infection of the sternoclavicular joint
- *Etiology*: hematogenous spread of bacteria often seen in drug addicts using unsterile needles, dialysis patients, and patients with subclavian catheters. Less common as a complication of local injections.
- *History*: Localized painful swelling of the sternoclavicular joint.
- *Examination*: Swelling, redness, tenderness to touch and pressure, and hyperthermia.
- *Diagnostics*: X-ray of the clavicle a.p. (to rule out changes to the bone), ultrasound (to visualize soft tissue swelling and eventual fluid accumulation), scintigraphy (increased tracer accumulation), blood tests (elevated erythrocyte sedimentation rate, leukocytes, and CRP), and arthropuncture can also be performed.
- *DD*: Tietze syndrome, arthritis in psoriasis, nonspecific sternoclavicular arthritis, sternoclavicular hyperostosis, sternoclavicular subluxation.

Specific Infections

Tuberculosis infection of the shoulder joint

Specific infection of the shoulder joint—either with pus (wet type) or without pus (dry type).
- *Etiology*: mostly hematogenous spreading from pulmonary or urogenital foci.
- *History*: nowadays rare. The *wet form* is common in the first two decades of life and leads to a rapid destruction of tissue involving massive production of pus. The *dry form*, *arthritis sicca*, is more common in old age and can lead to chronic joint swelling. The common inflammation signs are mostly absent, little pus production is seen, and joint destruction is limited.
- *Examination*: swelling of the shoulder. In the *wet form*, redness and hyperthermia. In the *arthritis sicca*, no redness, no hyperthermia, but tenderness to pressure along the clavicle and a painful limitation of shoulder mobility (Figs. 2.3, 2.4, 2.5, and 2.6).
- *Diagnostics*: X-ray of the shoulder in two planes (to rule out changes to the bone), ultrasound (to visualize soft tissue swelling), scintigraphy (increased tracer accumulation), blood tests (erythrocyte sedimentation rate, leukocytes, CRP slightly elevated), arthropuncture, a tuberculin skin test, gastroscopy (isolation of acid-fast bacilli).
- *DD*: rheumatic omarthritis, active omarthrosis, gout, pseudogout, nonspecific omarthritis.

Rheumatic Inflammation

Chronic polyarthritis

Rheumatic synovitis of the shoulder involving the bursae and the synovial sheaths. Can lead to rupturing of the rotator cuff and to secondary omarthrosis.
- *Etiology*: secondary damage caused by chronic rheumatoid inflammation of the joint.
- *History*: chronic swelling of both shoulder joints associated with localized pain that can radiate into the upper arms. Depending on the degree of damage, functional impairment can increase.
- *Examination*: in the early stages, patients may complain of bilateral tenderness over the intertubercular groove (tenosynovitis of the long head of the biceps tendon), as the disease progresses, additional subacromial tenderness, and tenderness at the coracoid process can present (Fig. 2.10), with severe swelling of the shoulder (subacromial bursa). Eventually, active mobility will be impaired (rotator cuff damage), positive drop arm test (the examiner performs a passive abduction of the patient's arms and asks the patient to slowly adduct both arms. The test is positive when the arm cannot be slowly adducted but falls down). Active elevation of the arm may become impossible. In advanced disease (secondary joint destruction), passive mobility may be limited.
- *Diagnostics*: X-ray of the shoulder in two planes (visualizing the damage to the joint), ultrasound (to visualize soft tissue damage or effusion), blood tests (erythrocyte sedimentation rate, leukocytes, and CRP elevated, especially during a flare-up, rheumatic factor may be positive.
- *DD*: omarthritis (nonspecific or specific), pseudogout, gout arthritis, calcifying tendinitis (acute stage).

Sternoclavicular arthritis in psoriasis (athroosteitis pustulosa)
- *Etiology*: seen in pustular psoriasis, a form of psoriasis vulgaris involving the palms of the hands and the soles of the feet.

- *History*: severe localized pain and elevation of the clavicle. Psoriasis—typical dermatology findings are found on the palms and the soles of the feet.
- *Examination*: psoriasis—typical skin findings, mostly, but not always, on the palms and the soles of the feet. Swelling and a palpable elevation of the clavicle. Localized tenderness.
- *Diagnostics*: X-ray of the clavicle a.p. (to rule out bone destruction), ultrasound (soft tissue swelling), scintigraphy (increased accumulation), blood tests (erythrocyte sedimentation rate, leukocytes, and CRP are eventually minimally elevated).
- *DD*: Tietze syndrome, nonspecific or septic sternoclavicular arthritis, sternoclavicular hyperostosis, sternoclavicular subluxation.

- **Traumatic disorders**

■ Sternoclavicular Joint: Subluxation and Dislocation

Subluxation and dislocation of the sternoclavicular joint as a consequence of soft tissue injury and in cases of joint malformation. One distinguishes between spontaneous, acute traumatic, and recurring post-traumatic dislocation. Regarding the direction of dislocation, one distinguishes anterior, caudal (rare), and retrosternal dislocation. Depending on the degree of instability, one distinguishes: grade I (distortion), grade II (subluxation), and grade III (dislocation).

- *Etiology*: spontaneous dislocation is possible in children and adolescents. More common is an indirect sideward force being exerted when falling onto outstretched arms. Another possibility is a force from above being exerted onto the shoulder of a person lying on his/her side (sport, motor vehicle accident). The medial end of the clavicle levers over the first rib and dislocates ventrally or caudally. The (less common) retrosternal dislocation occurs in direct trauma (force exerted on the medial end of the clavicle).
- *History*: mechanism of injury; localized pain at rest and pain during movement of the shoulder.
- *Examination*: localized swelling, tenderness to pressure in fresh injury. In older injuries, joint stability should be checked. Abduction and retroversion of the arm can provoke dislocation.

In cases of retrosternal dislocation, the trachea, the major blood vessels, and the vagus nerve can be injured. The examiner must look for dyspnea and a hoarse voice. Percussion and auscultation of the lungs should also be performed (hemathorax).

- *Diagnostics*: X-ray of the shoulder in two planes and the thorax (examining fracturing). CT or MRI scans of the sternoclavicular joint (dislocation direction, accompanying damage).

■ Clavicle Fracture

Fracture of the clavicle, mostly in the middle third of the bone.

- *Etiology*: mostly indirect trauma such as falling onto an outstretched upper extremity. In children, often falling from a tree or a tree house onto the shoulder. Classic horse riding injury.
- *History*: pain during breathing and during movement of the shoulder joint. Localized swelling and changes in the location of parts of the clavicle may be palpable.
- *Examination*: the medial fragment is mostly elevated above the lateral part. Applying pressure to the fragments to check for crepitation should be avoided as this is very painful.

Check and document motor function, sensory function, and perfusion to rule out injury of the brachial plexus or of the subclavian artery.

- *Diagnostics*: X-ray of the clavicle in two planes (visualizing a fracture).
- *DD*: acromioclavicular joint instability. In lateral fractures, involvement of the acromioclavicular joint needs to be considered.

■ Instability of the Acromioclavicular Joint

Recent or old subluxation or dislocation of the lateral clavicle after injury of the acromioclavicular ligament and the coracoacromial ligament. The Rockwood classification is used and distinguishes grade I to IV (extended Tossy classification).

- *Etiology*: direct blow to the clavicle by falling onto the shoulder with an adducted arm. Indirect trauma such as by falling onto an extended and slightly abducted arm. Also seen in sudden pulling at the arm (rare).
- *History*: in acute injury, localized pain, increasing according to the grade of damage. Pain can be absent in chronic instability. Depending on the grade of damage, increased instability and a change in the typical surface topography can occur.

- *Examination*:
  First degree (*distortion*): localized swelling and tenderness to pressure, no instability, normal range of motion.
  Second degree (*subluxation*): partly elevated lateral clavicle. All movement in the shoulder is painful, and the lateral end of the clavicle shows hypermobility.
  Third degree (dislocation): guarding posture, tenderness to pressure, elevation and abnormal mobility of the lateral end of the clavicle, positive piano key sign (Fig. 2.22, can be less pronounced due to swelling). Anterior–posterior mobility (Fig. 2.23).
  Fourth stage (*dorsal dislocation*): localized tenderness to pressure, dorsal dislocation of the lateral end of the clavicle. Easy to overlook, as there is no elevation of the clavicle! Horizontal instability (Fig. 2.23).
  Fifth grade (*cranial dislocation*): guarding posture, severe tenderness to pressure, positive piano key sign (Fig. 2.22), and an almost impossible to miss clavicular elevation.
  Sixth grade (*caudal dislocation*): mostly neurological and vascular damage is seen. Very rare.
- *Diagnostics*: X-ray of both shoulders a.p. with weights attached to the wrists (the joint space is much larger on the affected side than on the healthy side). It is important to rule out a lateral clavicle fracture.
- *DD*: separated shoulder, lateral clavicle fracture.

■ Traumatic Dislocation of the Shoulder Joint

Glenohumeral instability caused by a single direct or indirect trauma involving a lesion to the capsular ligament. Depending on the direction of the dislocation, one distinguishes between anterior, posterior, and inferior dislocation. Inferior dislocation is the rarest. Three degrees of injury are distinguished. In first-degree injury, the joint regains its stability after repositioning; in second-degree injury, the joint can be subluxated under anesthesia; and in third-degree, injury the joint remains unstable under anesthesia.

- *Etiology*: a direct trauma involving the proximal humerus (impact or a direct blow) is relatively rare. More common is the indirect trauma caused by extreme movement of the shoulder. Mostly caused by accidents. Less common are muscle contractions seen in seizures or in electric shock.
  Indirect anterior dislocation: occurs during violent abduction, elevation, and external rotation.
  Posterior dislocation: caused by axial compression and simultaneous adduction and internal rotation.
  Inferior dislocation: hyperabduction (rare).
- *History*: localized pain at rest and during movement, malpositioning of the arms.
- *Examination*: the surface topography of the shoulder reveals a dent at the lateral shoulder margin; the acromion appears very prominent. The arm is malpositioned and fixed. In inferior dislocation, the arm is fixed in the malposition in an abducted position (comparison to the other side is key!). Tenderness to pressure over the dislocated humeral head, pain aggravation in anterior dislocation when abduction and external rotation is performed. Although rare, it is important to think of accompanying injury to nerves and blood vessels. Motor function, perfusion, and sensory function need to be checked and documented after relocation.
- *Neurology*: axillary nerve injury (15 %; anesthesia over the deltoid muscle), less common in parts of the ulnar nerve (ulnar claw) (Fig. 2.57) or the median nerve (hand of benediction) (Fig. 2.56).
- *Blood vessels*: paleness and loss of the radial pulse in case of injury to the axillary artery (rare).
- *Diagnostics*: X-ray of the shoulder in two planes (to visualize the dislocation and rule out any changes to the bone or associated injury.)

■ Anterior Post-traumatic Subluxation of the Shoulder (Dead Arm Syndrome)

Special form of traumatic shoulder dislocation. Subluxation of the humeral head through abduction, elevation, and external rotation (*throwing movement*). *The humeral head presses on the plexus.*

- *Etiology*: damage to the anterior, lower labrum caused by a single primary dislocation or repeated microtrauma.
- *History*: a sudden pain is felt during the movement that causes the dislocation. The arm drops as if paralyzed and cannot be moved for some seconds. In some cases, dysesthesia can be present for hours.
- *Examination*: positive apprehension test (Fig. 2.17), positive sulcus sign (Fig. 2.19), palpable snapping as a sign of subluxation.

- *Diagnostics*: X-ray of the shoulder in two planes, MRI (to determine damage to the joint cup, a Hill–Sachs lesion at the posterior margin of the humeral head, the rotator cuff, and the biceps tendon).

Recurrent Post-traumatic Shoulder Dislocation

Recurring shoulder dislocation after a primary traumatic dislocation.

- *Etiology*: as a consequence of traumatic shoulder dislocation.
- *History*: traumatic shoulder dislocation, and then recurrent dislocation that occurs with increasing frequency and is easily provoked. Relocation is not possible during the first dislocations. Bilateral dislocation is very rare.
- *Examination*: if a patient presents with a dislocated shoulder, one can commonly see a dent in the surface topography of the shoulder or a fixed position of the arm. After the shoulder is relocated, stability tests are positive (anterior apprehensions test, Fig. 2.17; sulcus sign, Fig. 2.19; posterior apprehension test, Fig. 2.18).
- *Diagnostics*: X-ray of the shoulder in two planes, MRI (to check for damage to the glenoid cavity, Hill–Sachs lesion at the posterior margin of the humeral head, the rotator cuff, and the biceps tendon).
- *DD*: habitual dislocation of the shoulder.

Scapula Fracture

Fractures of the scapular body, the coracoid process, the surgical neck of the humerus, the anatomical neck, as well as other parts of the joint.

- *Etiology*: mostly in cases involving serious injury with severe trauma or in complex injuries of the shoulder.
- *History*: localized swelling, painful limitation of mobility.
- *Examination*: deformed contours of the shoulder, subcutaneous hematoma, localized tenderness to pressure, painful limitation of mobility in the shoulder.

Take care not to miss associated injury: clavicular fracture and shoulder dislocation. Also consider neurological damage: axillary nerve, suprascapular nerve, and brachial plexus.

- *Diagnostics*: X-ray of the shoulder in two planes and the axial scapula (examining the fracture and to rule out any further injury to the bones).

Proximal Humerus Fracture

Fractures at the surgical neck of the humerus and at the anatomical neck as well as avulsion fractures of the greater tuberosity. In some cases, damage to the axillary nerve occurs. Vascular damage can also occur.

- *Etiology*: direct fall onto the arm or onto the open hand.
- *History*: occurs in adults and children. Acute pain. The injured side is often held by the hand of the opposite side.
- *Examination*: localized tenderness to pressure and movement. Mobility is painfully limited but can still be surprisingly good in cases of compressed fracture. In case the axillary nerve is injured, the deltoid muscle does not contract when the patient attempts to abduct the arm and sensory function over the shoulder region is impaired.
- *Diagnostics*: X-ray of the upper arm in two planes to visualize the fracture.

Humeral Shaft Fracture

Diaphysis fracture of the humerus. Spiral fracture in the middle third and a transverse fracture in the humeral shaft. Stable fractures usually present as long spiral fractures and fractures of the middle of the shaft. Injury to the radial nerve and the arteries is possible.

- *Etiology*: falling onto outstretched arms (spiral fracture) or a direct blow to the upper arm (transverse fracture). Metastasis in the proximal half of the humerus shaft.
- *History*: pain and swelling in the upper arm, guarding.
- *Examination*: obvious and painful impairment in the mobility of the shoulder and elbow. The combination of wrist drop (Fig. 2.55) and sensory loss at the back of the hand point toward radial nerve injury. The radial pulse should also be checked.
- *Diagnostics*: X-ray of the upper arm in two planes.

- **Tumor disorders**

Primary Tumors

Pancoast tumor

Special form of lung cancer, mostly located in the apical lung with early infiltration of the thoracic wall (*see* Chapter 1).

Enchondroma

Rare benign, cartilage tumor. Very common in the phalanges, often in the long bones and in the flat bones. Less common in the small long bones. Very rare in carpal and tarsal bones. High ability to metastasize elsewhere if the tumor cells are opened during surgical resection.

- *History and examination findings*: nonspecific. Often symptom-free. Common incidental finding in scintigraphy.
- *Diagnostics*: X-ray of the shoulder in two planes (localization and extent). Biopsy.

Unicameral bone cyst, solitary juvenile bone cyst

Probably the most common bone tumor. Commonly seen in the proximal humerus and the proximal femur. Also in the tibia and at the calcaneus.

- *Etiology*: tumor disorder of unknown primary tissue.
- *History*: can present in young children between the age of 8 and 15. Mostly symptom-free, in some cases, pain is felt at rest and upon loading. In some cases, spontaneous fracture.
- *Examination*: nonspecific. In some cases fracturing.
- *Diagnostics*: X-ray of the affected region in two planes (localization, extent, fracturing). Scintigraphy (to rule out accumulation).

- **Neurological disorders**

Entrapment of the Suprascapular Nerve in the Scapular Notch

- *Etiology*: mostly following indirect trauma such as falling onto outstretched arms. Less common is chronic compression in athletes (gymnasts). Congenital narrowing at the suprasternal notch or at the transverse scapular ligament.
- *History*: pain at the acromioclavicular joint, pain at the posterior and lateral shoulder, pain at night, weakness in the shoulder.
- *Examination*: atrophy of the supraspinatus muscle and the infraspinatus muscle. Weakness of external and internal rotation and abduction. Limited active mobility of the shoulder joint. Very painful passive adduction (Fig. 2.5).
- *Diagnostics*: X-ray of the shoulder in two planes (to rule out pathological changes to the bone). Neurological consultation.

Median Nerve (C5–T1) Injury at the Upper Arm

- *Etiology*: humerus fracture, anemia, compression injury caused by a partner lying or falling asleep with their head on the patient's arm.
- *History*: weakness felt when gripping. Loss of sensory function (exclusive to the hand)
- *Examination*: typical is the hand of benediction, seen when the patient attempts to make a fist (Fig. 2.56). Hypesthesia at the thenar eminence and at the palmar side of the radial three and a half fingers (Fig. 2.24).
- *Diagnostics*: X-ray of the shoulder in two planes (to rule out pathological alterations to the bone). Neurological consultation (electromyography, electroneurography, new or old damage, denervation, repair).

Injury to the radial nerve (C5–Th1) at the upper arm

This injury at the upper arm mostly occurs in the radial sulcus, less commonly in the axilla. Radial nerve palsy is relatively common.

- *Etiology*: fracturing at the shaft of the humerus, compression, Saturday night palsy, crutch palsy.
- *History*: weakness of the arm and the hand. Sensory function loss at the back of the hand and the lower arm.
- *Examination*: wrist drop (Fig. 2.55). Hypesthesia at the radial/dorsal two and a half fingers, the back of the hand, and the dorsal lower arm (Fig. 2.24). In case the injury is located at the axilla (e.g., crutches), active extension in the elbow is impaired and there is hypesthesia (sensory function will be intact in case of humerus shaft fracture or Saturday night palsy).
- *Diagnostics*: X-ray of the upper arm in two planes. Neurological consultation (electromyography, nerve conduction velocity, new or old injury, denervation, repair).

2.3 Elbow

2.3.1 Systemic Examination

- **Local findings**

Axis/position	Degree physiological/pathological (right/left)	Cubitus valgus/cubitus varus
Swelling/redness/ hyperthermia	No; if present, then:	Localization/extent/scope/consistency (soft/rough/displaced) rheumatoid nodules
Hematoma/abrasion/ open wound/scab	No; if present, then:	Localization/extent/scope
Scarring	No; if present, then:	Localization/extent/scope/consistence (soft/rough/displaced)
Muscles	Biceps muscle Triceps muscle Other flexor and extensor muscles in the lower arm Biceps during flexion against resistance	Highly developed/wasted/shortened Atrophy (significant?), muscle tone increase or decrease (right/left) Muscle belly distalized/not distalized
Hematoma/abrasion/open wound/scab	Highly developed/wasted/ shortened Atrophy (significant?) (right/left)	Biceps, triceps, forearm flexors, extensors
	Muscle belly distalized/not distalized	M. biceps brachii in flexion against resistance
Circumferences	--cm (right/left)	10 cm above the epicondyle med. Height epicondyle med. 10 cm below the epicondyle med. Wrist
Mobility elbow	Extension/flexion Pronation/supination	––/––/–– Degrees (passive, right/left)
Crepitation	No; if present, then:	Fine/coarse (left/right)
Elbow pain	No; if present, then:	Motion pain (active/passive) Tenderness: epicondyle med./lat. radial head, sulcus ulnar nerve, forearm (flexor surface/extensor side) Pain on movement against resistance (extension/flexion, pronation/ supination) Cozen test
Hoffmann–Tinel	Negative/positive (right/left)	Volar forearm (proximal/distal)
Lateral ligaments	Stable/increased expandability (medial/lateral, right/left)	In a neutral position
Amputation stump length	Medial epicondyle—butt end	--cm (right/left)

- **Neurology**

Reflexes	Biceps tendon (C5) Triceps tendon (C7) Radius periost (C6)	Vigorous/decreased/absent/supernormal (hyperreflexic) (right/left)
Sensory examination	Dermatome (segment or nerve assignable/not exactly assignable)	Hypesthesia/paresthesia/Dysesthesia (right/left)
Motor function examination	Elbow flexion (C5/C6) Elbow extension (C7) Pronation (C6–Th1) Supination (C5/C6) Hand diffraction (C6–Th1) Hand stretching (C6/C7) Wrist drop (radial nerve) Hand of benediction (median nerve) Ulnar claw (ulnar nerve) Finger pinch grip (D1 to D2) Froment's sign	Intact/attenuated (M0–M1–M2–M3–M4–M5) (Right left)

- **Circulation**

Arteries	Axillary artery Radial artery	Fully/barely/not palpable
Veins	Venous stasis	(Right/left)
Capillary pulse	Fingertips	Present/absent (right/left)

Fig. 2.25 Determining the arm holding angle

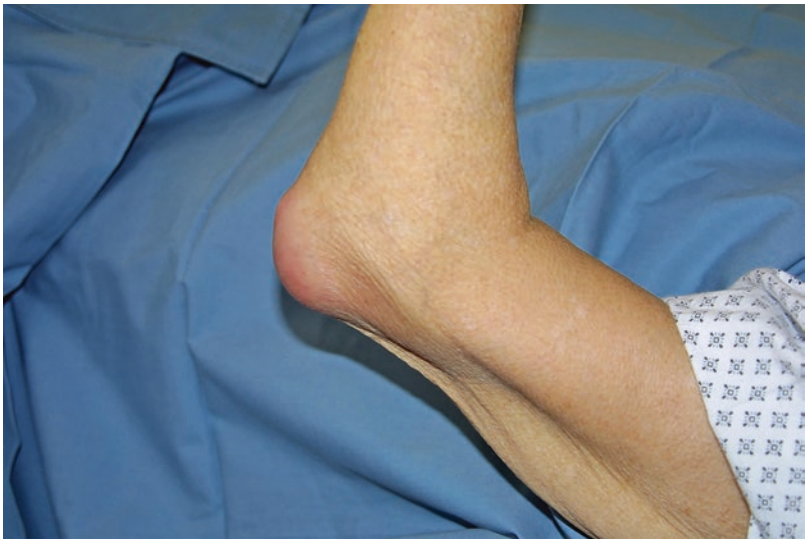


Fig. 2.26 Swelling over the olecranon in chronic bursitis

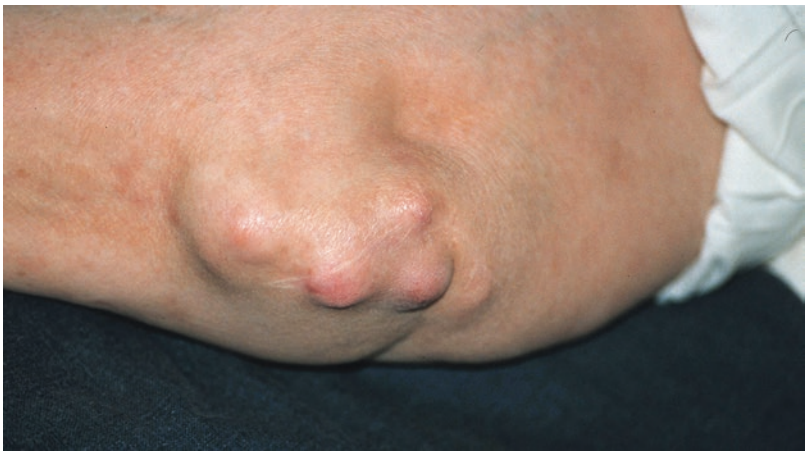


Fig. 2.27 Rheumatoid nodules in the elbow

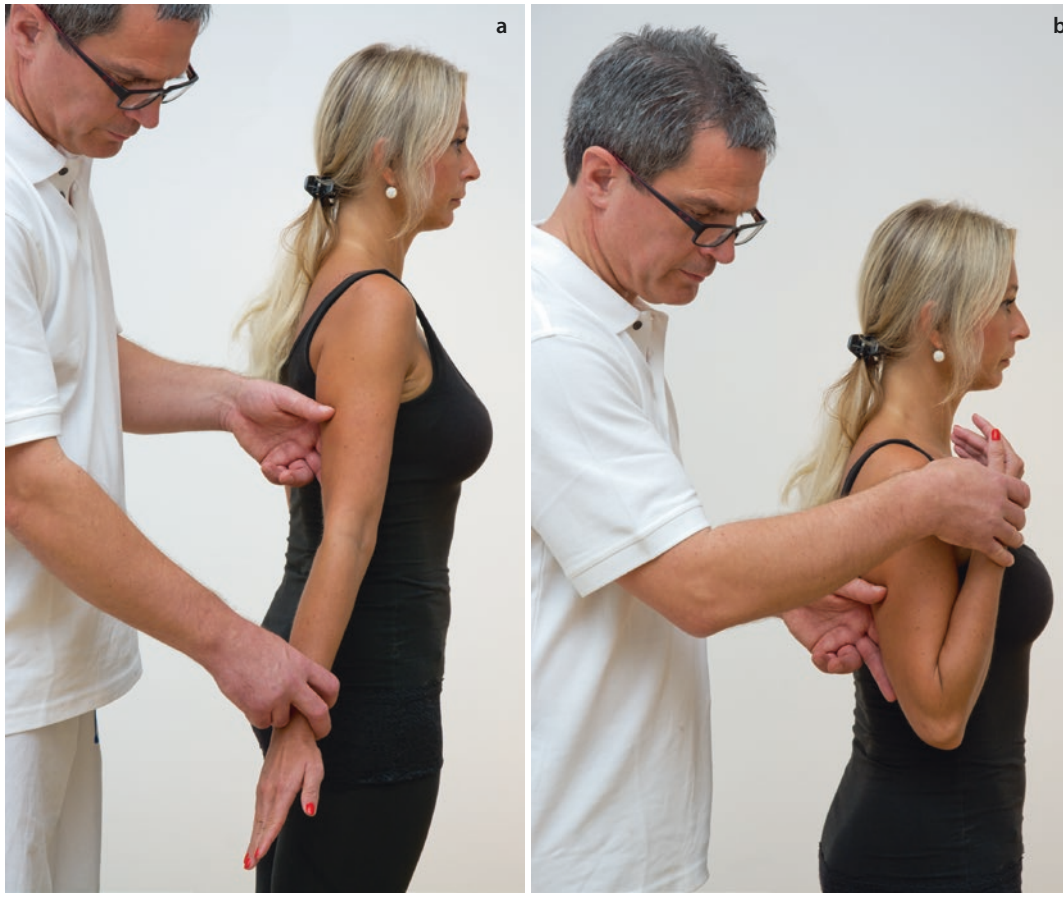


Fig. 2.28 (**a**, **b**) Testing extension/flexion in the elbow. Normal ROM: 10-0/0/150°

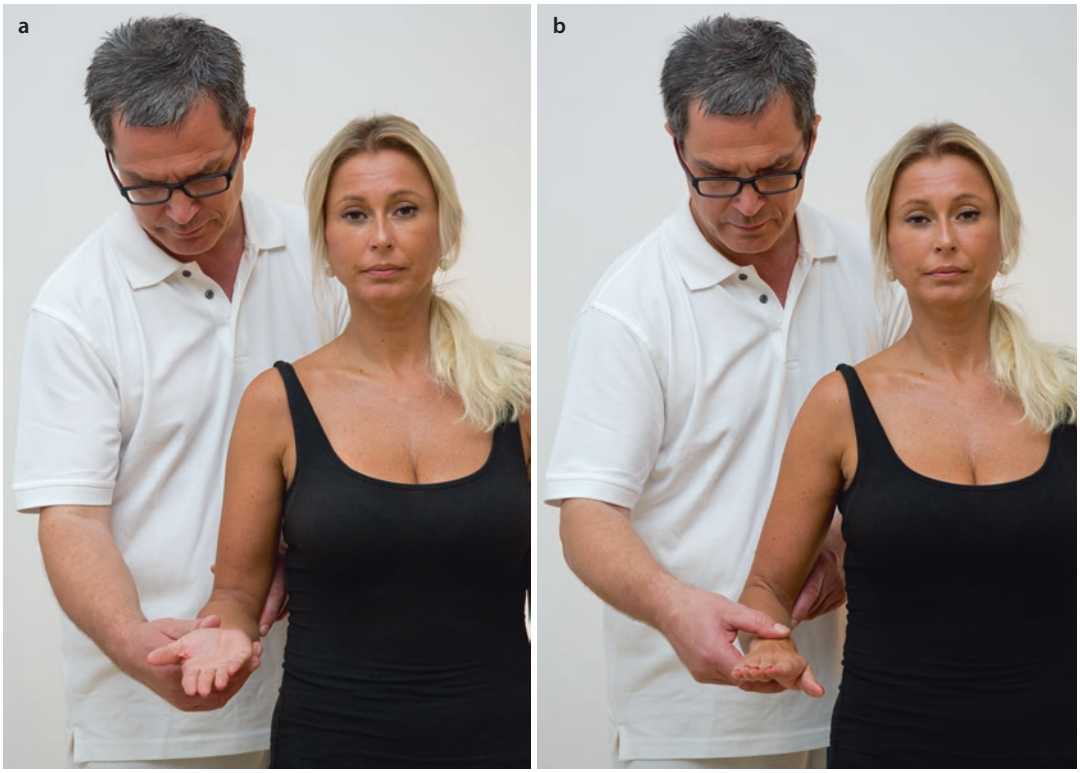


Fig. 2.29 (**a**, **b**)Testing pronation/supination in the elbow. Normal ROM: 80-90/0/80-90°

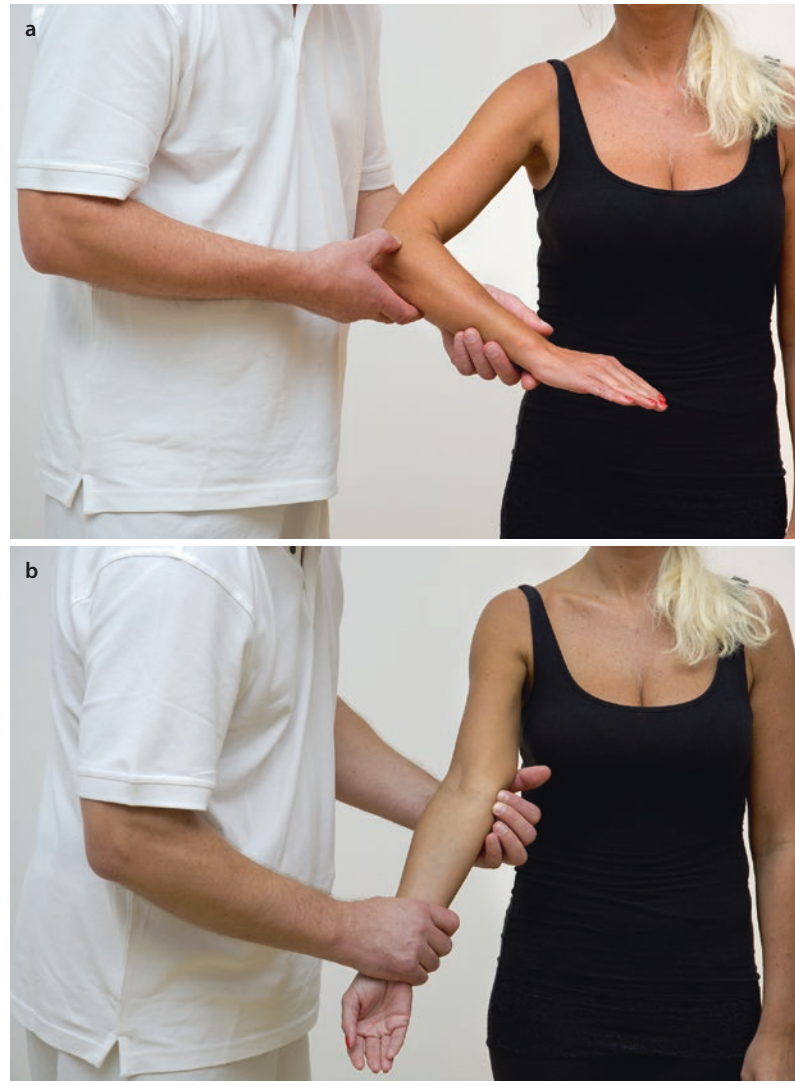


Fig. 2.30 (**a**, **b**) Testing tenderness at the elbow: radius head (**a**), medial epicondyle (**b**), and lateral epicondyle. The radius head is palpable distal to the radial epicondyle. (l) During flipping movement of the lower arm, the rotation of the radius head can be palpated. In cases of radius head fracture, tenderness is present at the head, and the flipping movement of the lower arm is painful. In radial epicondylitis, tenderness is present at the lateral epicondyle; in ulnar epicondylitis, tenderness is present at the medial epicondyle (**b**)

Fig. 2.31 (**a**, **b**) Cozen test (**a**): in medial radial epicondylitis (tennis elbow), the hand is dorsiflexed against resistance. This elicits pain over the radial epicondyle, because the receptor muscles insert there and are tautened. Often tenderness over the radial epicondyle is present. Inverted Cozen test (**b**): in ulnar epicondylitis (golfer's elbow), the hand is palmar flexed against resistance. By contracting the flexor muscles, pain is elicited over the ulnar epicondyle. Often, tenderness to pressure is present at the ulnar epicondyle

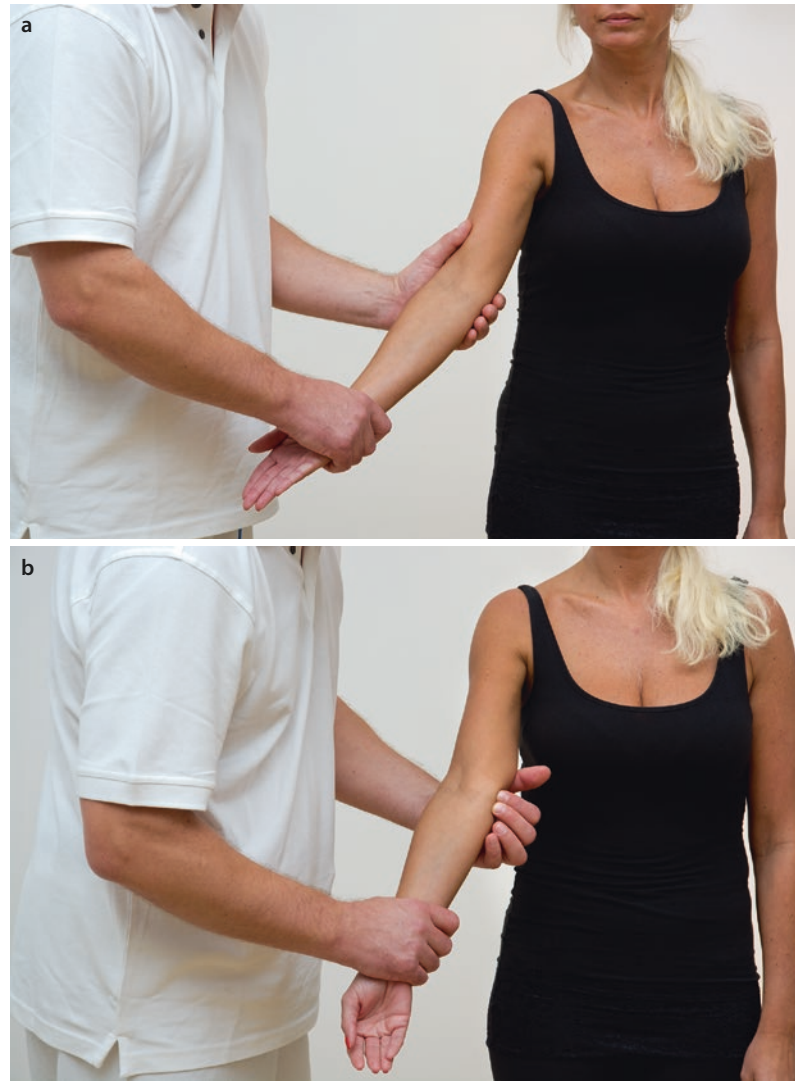


Fig. 2.32 (**a**, **b**) Testing collateral ligament stability in the elbow: the ulnar ligament is tested in a slight flexion position, in supination, and in a neutral position of the lower arm by applying valgus stress (**a**), the radial ligament by applying varus stress to the stretched and pronated elbow (**b**)

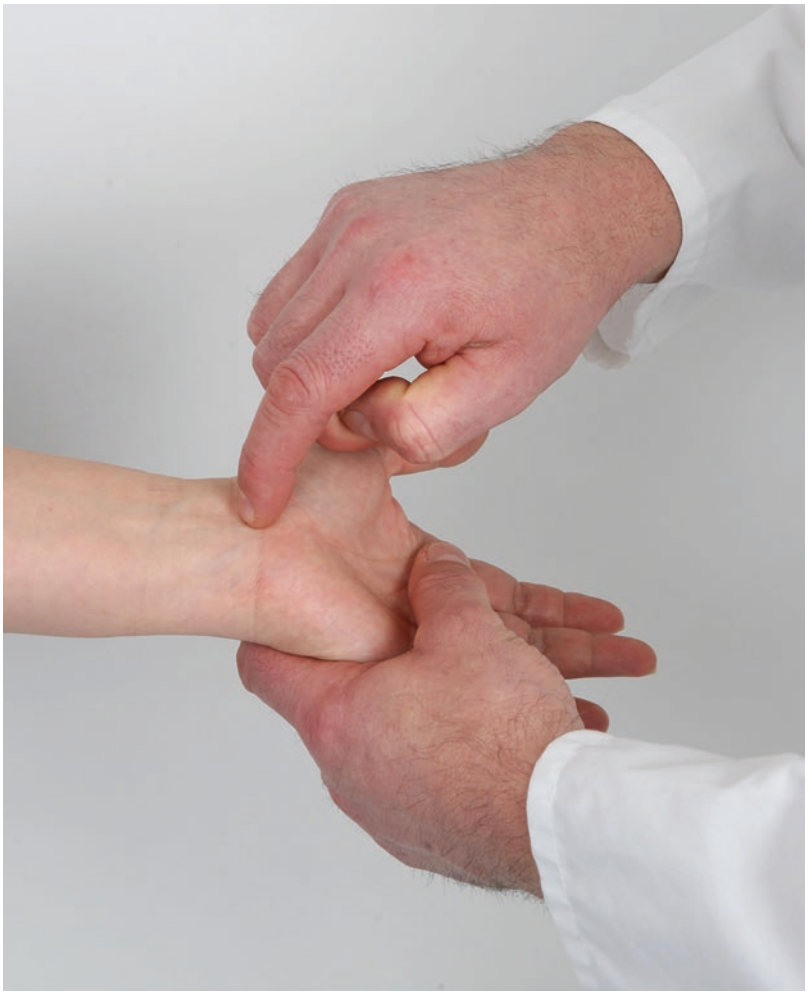


Fig. 2.33 Tinel's sign: serves to test if impingement of the median nerve (compression) exists. The sign is positive if tapping the median nerve at the flexor side of the lower arm at the wrist causes pain and paresthesia. Tinel's sign can also be provoked in other nerves, e.g., the ulnar sulcus of the elbow. Following nerve adaptation, the test can be used to determine nerve regeneration. A positive sign then indicates the beginning of nerve regeneration

Fig. 2.34 Testing the tweezer grip of the index finger and the thumb (median nerve). Function is disturbed if the two fingers cannot form an "O"

Fig. 2.35 Froment's sign serves to examine the ulnar nerve function. The patient is asked to hold a sheet of stiff paper between the thumb and the index finger. The examiner pulls the sheet away. The sign is positive if the patient flexes the thumb in the interphalangeal joint in order to hold onto the sheet. In a positive case, the distal phalanx of the thumb is flexed to compensate for the adductor weakness (flexion is a function of the median nerve)

2.3.2 Leading Symptoms of the Elbow

The leading symptoms of the elbow are summarized in Table 2.2.

2.3.3 Disorders

- **Clinical pictures**

Cubitus Valgus/Varus

A small degree of valgus at the elbow is physiological in the extended elbow. In men, the physiological valgus is about 10° and in women about 20°.

- *Etiology*: often seen following supracondylar humerus fracture. Varus often occurs following fractures at the medial epicondyle. Valgus deformity often presents following radial head dislocation or fracture that was not optimally relocated. In rare cases congenital.
- *History*: malposition and impaired range of motion.
- *Examination*: increased varus and valgus position of the extended lower arm and elbow. Impairment of pronation/supination and extension/flexion.
- *Diagnostics*: X-ray of the elbow in two planes (to clarify the etiology).
- *DD*: depends on the etiology.

Lateral and Medial Epicondylitis

Pain at the lateral epicondyle (tennis elbow—more common) or at the medial epicondyle (golfer's elbow).

- *Etiology*: excessive stress on the tendons due to work or sports (typing, using screwdrivers, playing piano, tennis, golf, fencing, throwing).
- *History*: commonly present in patients between 40 and 50. Mostly medial epicondylitis. Chronic pain presenting as pain at rest and under loading.
- *Examination*: severe localized tenderness at the muscle insertion site. Lateral epicondylitis: pain when making a fist and during dorsal extension of the hand and stretching the middle finger against resistance. Positive Cozen test (Fig. 2.31).

Diagnostics: X-ray of the elbow in two planes (to rule out pathological changes to the bones).

Volkmann's Contracture

Secondary contracture at the lower arm and hand. The contracture is a result of ischemia or necrosis of tissue caused by obstructed arteries or tissue injury in compartment syndrome. Leads to damage in the lower arm and hand muscles that show hypotrophy and become weakened.

- *Etiology*: compression of the brachial artery by tight casts, e.g., in humerus fracture. Compression injury to soft tissue or fracture interrupting venous blood flow in tissue.

Table 2.2 Leading symptoms of the elbow

History	Pain	Local findings, functional tests	Sensory function disorder	Motor function disorder	Points to
Elbow pain (tennis player)	Radial pain at rest and during exercise	Tenderness epicondylitis humeri radialis. Painful fist and dorsiflexion and extension of the middle finger against resistance	None	None	Epicondylitis radialis
Elbow pain (golfer, bowler)	Ulnar pain at rest and during exercise	Tenderness over the medial epicondyle of the humerus pain during palmar flexion against resistance	None	None	Epicondylitis ulnaris
Toddler. Was pulled up on the arm as stumbled. Elbow is pressed in posture to the trunk	Acute pain in the elbow	Movement pain esp. in flexion. Pronation limited painful, no local tenderness	None	None	Radial head dislocation
Impaction in the elbow (more often men)	Knife-prick pain at movement and load	Possibly swelling, flexion and extension deficit	None	None	Chondromatosis
Begins with numbness and tingling of the little finger (telephone operator, epicondylar fracture in childhood)	Drawing pains to fourth and fifth fingers	Froment's sign positive	Atrophy hypothenar and interosseous space 1. Claw hand	Hypoesthesia of the little finger, ulnar half of the ring finger, ulnar side of the hand, and palmar half	Sulcus ulnaris syndrome
Mostly boys, pain in the elbow without accident	Stress pain	Pressure pain over the radial head, painful extension deficit, pain at the end of the extension	None	None	M. Panner
Lacing associations, for example, by fracture, swelling of the fingers	Lasting and cramping pain	Finger bluish, swollen, and cool	Possible over	Possible over	Beginning of Volkmann's contracture

- *History*: common in children. Persistent and cramp-like pain. Signs of venous return interruption in the form of swelling at the fingers. Permanent deformity and functional impairment are often the consequence.
- *Examination*: fingers are swollen, livid, and cool to touch. Pain is aggravated by active contraction and passive stretching of the muscles. The pulse is mostly palpable (compare to the opposite side!). Sensory function loss and motor function loss are also possible.
- In the course of the disorder, flexion contracture at the wrist as well as at the middle and distal joints of the fingers with overextended metacarpophalangeal joints. Adduction contracture of the thumb. Bunnell test positive (passively flexed metacarpophalangeal joint: proximal and distal interphalangeal joints can be actively flexed; if the metacarpophalangeal joint is fixed in extension, active and passive flexion of either the proximal or the distal interphalangeal joints becomes impossible; consequence of a shortening of the interosseous muscles).

This disorder should always be prevented! *A patient with a cast who complains about pain must always be believed*!

- *Diagnostics*: the examiner firstly bases the diagnosis on patient history and on the physical examination.

- **Congenital malformations and metabolic disorders**

■ *Madelung's Deformity*

Growth disturbance of the epiphyseal growth plane of the radius epiphysis. The deformity presents with a radially directed dislocation of the wrist. A combination of deformity affecting both wrists is possible as well as a deformity that affects multiple skeletal bones.

- *Etiology*: congenital. Familial (autosomal dominant). The genetics of the less severe forms are still unclear. Girls are affected four times more commonly than boys.
- *History*: mostly presents between the ages of 8 and 13. Shortening and deformity of the radius leads to a malpositioning of the hand. As growth progresses, the condition can worsen. Pain is the leading symptom and mobility is impaired.
- *Examination*: mostly both sides of the wrist are affected. Physical findings include a limited mobility of the hand (Figs. 2.43 and 2.44), a prominent styloid process, and radial clubbing in the hand.
- *Diagnostics*: X-ray of the lower arm in two planes (to visualize the deformity).

■ *Radioulnar Synostosis*

Osseous union between the radius and the ulna in the proximal third, mostly in a pronated position.

- *Etiology*: familial occurrence, in some cases genetic.
- *History*: functional impairment of the hand (limited pronation and supination). Mostly only noticed in preschool-aged children as the disorder is compensated for by the hypermobility of the fingers. Can present unilaterally or bilaterally.
- *Examination*: complete loss of pronation and supination (Fig. 2.29).
- *Diagnostics*: X-ray of the lower arm in two planes (to visualize the deformity).

■ *Panner Disease*

Avascular necrosis of the capitulum humeri.

- *Etiology*: unknown. Mechanic–traumatic, vascular, and constitutional hypothesis.
- *History*: mostly affects boys between the ages of 7 and 10. The right elbow is more commonly affected. Patients often report some trauma in the past. Pain is experienced in the elbow at rest and is aggravated by loading. Little impairment to range of motion.
- *Examination*: localized swelling above the radial head. Localized tenderness to pressure at the radial head (Fig. 2.30). Extension is impaired in the elbow and painful when approaching full extension.
- *Diagnostics*: X-ray of the elbow in two planes and MRI (to visualize necrosis).

- **Degenerative disorders**

■ *Arthrosis of the Elbow Joint*

Primary and secondary degenerative disorder of the elbow joint

- *Etiology*: primary arthrosis is possible, but secondary is much more common. Secondary arthrosis results from malpositioning or post-traumatically, in the context of chronic polyarthritis, inflammation,

chondromatosis, and avascular necrosis (Panner disease).
- *History*: often symptom-free over a long period of time. In the course of disease, patients complain of morning stiffness, pain when applying load to the joint, and mobility impairment.
- *Examination*: tenderness to pressure and swelling, partly fluctuating (only in active arthrosis). In some cases, coarsening of the joint contours. Extension and flexion deficits are common (Fig. 2.28).
- *Diagnostics*: X-ray of the elbow in two planes (differential diagnosis).
- *DD*: especially chondromatosis.

- **Inflammatory disorders**

Nonspecific Inflammation

Elbow bursitis

In chronic cases, caused by long-term wear to the subcutaneous bursa. In acute cases, a purulent inflammation.
- *Etiology*: *chronic* after excessive pressure on the bursa (desk work) and in chronic polyarthritis. *Acute purulent* as a complication caused by bacterial infection after injury causing a skin lesion.
- *History*: *chronic bursitis* sets in slowly and is barely painful. Swelling is seen at the olecranon. *Acute purulent bursitis* presents with pain and localized swelling at the elbow.
- *Examination*:
  Chronic bursitis: more or less severe swelling at the olecranon (Fig. 2.26) with a pasty or fluctuating consistency. Smooth surface covered by movable skin. Very little tenderness to pressure.
  Acute purulent bursitis: swelling, redness, hyperthermia. Severe tenderness to pressure.
- *Diagnostics*: blood tests (erythrocyte sedimentation rate, leukocytes, CRP—clarify etiology, activity of the process).
- *DD*: acute or chronic bursitis, chronic polyarthritis (rheumatoid nodules—Fig. 2.27, total clinical picture).

- **Traumatic disorders**

Injury to the Elbow Bursa

Traumatic injury of the bursa at the elbow.
- *Etiology*: *open injury* by a direct blow. *Closed injury* by trauma induced by a blunt instrument.
- *History*:
  Open injuries: painful injury of the skin.
  Closed injury: swelling at the elbow. Livid coloring of the skin.
- *Examination*:
  Open injuries: the wound margins are smooth or frayed. A viscous liquid pours out.
  Closed injuries: swelling, hematoma, localized tenderness to pressure. In rare cases movement impairment.
- *Diagnostics*: X-ray of the elbow in two planes (to rule out bone injuries).

Subluxation of the Radial Head

Subluxation of the radial head from the annular ligament that becomes trapped between radial head and capitulum humeri. Only in toddlers.
- *Etiology*: consequence of sudden axial pulling at the extended and pronated arm, e.g., when a parent lifts a child up when it stumbles.
- *History*: the child guards the arm by pressing it to the trunk without moving it.
- *Examination*: no localized tenderness to pressure! Pain under certain movements, especially during flexion. Pronation is painfully reduced (Fig. 2.29).
- *Diagnostics*: X-ray of the elbow in two planes (to visualize the dislocation).
- *DD*: radial neck fracture.

Radial Head Dislocation

Dislocation of the radial head, mostly in combination with ulnar fracturing (Monteggia fracture–dislocation). Uncommon in adults.
- *Etiology*: falling onto a pronated arm. Rarely congenital. Recurring radial head dislocation also after an overlooked primary dislocation in Monteggia fracture–dislocation.
- *History*: falling, pain, guarding.
- *Examination*: localized swelling and tenderness to pressure. Visible and palpable prominency of the radial head.
- *Diagnostics*: X-ray of the lower arm with the elbow and the wrist in two planes (to visualize the dislocation and rule out any accompanying injury to the bones).

Elbow Dislocation

Dislocation in the humeroulnar joint. Often accompanied by fractures of the coronoid process and of the radial head. Relatively common in children but also in adults.

- *Etiology*: mostly after trauma, such as a fall on the hand with a slightly flexed elbow. Rarely also congenital.
- *History*: mostly posterior dislocation of the ulna, rarely dorsolateral or dorsomedial. The elbow is very painful and swollen. Injury to the brachial artery is rare.
- *Examination*: clear swelling of the elbow. The olecranon stands proximal to the connecting line between the two epicondyles. Tenderness to touch and pressure.

Check for injury to the median, ulnar, and radial nerve as well as the brachial artery.

- *Diagnostics*: X-ray of the elbow in two planes to show the dislocation and to rule out other injury to the bones (comparative imaging of the contralateral elbow if not clear).

Distal Fracturing of the Humerus

Supra-, trans-, and epicondylar fractures, located either intra- or extra-articularly. In children, mostly supracondylar fractures, epiphyseal loosening with or without a metaphyseal wedge, epiphyseal fractures. Injury to the radial, ulnar, and median nerve possible. In supracondylar fractures, the brachial artery is easily injured.

- *Etiology*: mostly indirect trauma after falling onto outstretched arms or in a direct fall onto the elbow.
- *History*: fall, swelling, guarding, and malposition.
- *Examination*: swelling with tenderness at the distal humerus. A physiological axis deviation is possible (Fig. 2.25). Sideward instability is common as well as a painfully limited range of motion in the elbow.
- The following may be found: drop wrist (Fig. 2.55) and sensory function loss at the back of the hand (radial nerve); ulnar claw (Fig. 2.57) and sensory function loss at the ulnar side of the lower arm and the back of the two ulnar fingers (ulnar nerve) (Fig. 2.24); hand of benediction (Fig. 2.56) with sensory function loss at the radial side of the palm and the first three fingers (median nerve) (Fig. 2.24).
- The radial artery pulse must be checked (brachial artery injury).

Epicondylar fracturing mostly occurs in combination with elbow dislocation. Both are rare in adults. In children, this fracture forms the most commonly overlooked elbow injury, because the bones of the not-yet-formed trochlea are not radiologically visualized.

- *Diagnostics*: X-ray of the elbow in two planes (visualizing the fracture).

Fracturing in Both Lower Arm Bones

Fracture of the ulna and the radius

- *Etiology*: mostly as a result of a fall with outstretched arms or due to a direct blow to the lower arm.
- *History*: fall followed by a painful lower arm and a visible deformity.
- *Examination*: swelling, hematoma, and axis deviation possible (Fig. 2.25). Localized tenderness to pressure. Elbow and wrist mobility painfully limited.
- *Diagnostics*: X-ray of the lower arm with the elbow and the wrist in two planes.

Ulnar Fracture

Isolated fracture of the ulnar shaft

Rare fracture of the ulna, mostly as a consequence of a direct blow to the ulnar side of the lower arm. At first, an associated radius head dislocation must be ruled out (Monteggia fracture).

Monteggia fracture

Ulnar shaft fracture with a simultaneous dislocation of the head of the radius.

- *Etiology*: fall onto the pronated arm. Less common is a direct blow to the proximal ulna or hyperextension trauma.
- *History*: fall or blow, painful underarm, and swelling. Fracture often visible. Dislocation of the head of the radius is not always obvious! Painful reduction of mobility in the hand.
- *Examination*: localized swelling. Axis deviation is possible. Fracture ends could be visible under the skin. Instability. Head of the radius is palpable in the elbow (less common is posterior dislocation). In this case, there is a localized tenderness in the area of the fracture.

Often overlooked in children as the ulna fracture is then a greenstick fracture.

- *Diagnostics*: X-ray of the lower arm with the elbow and wrist in two planes.

Fracture of the coronoid process

Mostly a fracture that presents in connection with a dislocation of the elbow. Can be accompanied by instability.

Fracture of the olecranon

Mostly in older patients, sometimes in children.

- *Etiology*: mostly a direct fall onto the elbow. In some cases also as a consequence of a strong contraction of the triceps muscle.
- *History*: pain. Severely swollen elbow with clear hematoma.
- *Examination*: swelling at the elbow, hematoma, localized tenderness to pressure. Extension against resistance is painful and weakened or impossible.
- *Diagnostics*: X-ray of the elbow in two planes (to visualize the fracture).

Distal Radius Fracture

According to the Frykman classification, the distal radius fracture is divided into types 1–8, depending on the involvement of the radiocarpal joint and the distal radioulnar joint and whether there is an associated ulnar fracture. The most important types of distal radius fracture include the ***Colles fracture*** (*extension fracture*), *the* ***Smith fracture*** (*flexion fracture*), *and the* ***green stick fracture*** *of the distal radius in combination with an associated fracture of the ulna.*

- *Etiology*: fall onto the outstretched or flexed hand.
- *History*: mostly in children or in older patients (mostly women). Fall, pain at rest, swelling, deformity, and malposition of differing degrees.
- *Examination*: swelling of the wrist, tenderness to pressure, decreased range of motion. In a Colles fracture, the bayonet deformity of the hand is seen. Less common as an early complication, yet quite common as a late complication, is the sensory function loss of the median nerve (Fig. 2.24, radial side of the palm).

Always examine the elbow as well (*Galeazzi fracture*).

- *Diagnostics*: X-ray of the lower arm with the elbow and wrist in two planes (to visualize a fracture).

Radius shaft fracture

Extremely rare fracture, mostly as a consequence of a direct blow to the lower arm. Often in combination with dislocation of the distal ulna (*Galeazzi fracture*).

Galeazzi fracture

Shaft fracture of the distal third of the radius with simultaneous dislocation of the ulna.

- *Etiology*: fall onto the outstretched hand.
- *History*: painful lower arm and decreased range of motion in the hand and the elbow. Not always painful in the hand! Fracture ends are unstable!
- *Examination*: visible and palpable deformity in the area of the fracture, axis deviation, swelling, localized tenderness to pressure, painful movement impairment.
- *Diagnostics*: X-ray of the lower arm with the elbow and the wrist in two planes.

Fracture of the head of the radius

Fracture of the head of the radius. As a vertical splitting of the head of the radius, a simple osseous avulsion and as a comminuted fracture. Relatively common.

- *Etiology*: fall onto outstretched arm.
- *History*: common to all age groups. Fall, painful elbow, fixing the arm with the opposite hand.
- *Examination*: swelling, hematoma, localized tenderness at the head of the radius (Fig. 2.30). Painful movement—especially pronation and supination (Fig. 2.29)—extension limited.
- *Diagnostics*: X-ray of the elbow in two planes (visualizing the fracture). Some dislocated fractures are only detected via imaging in other planes.

Radial head fracture

Fracture of the radial head. Mostly observed in children.

- *Etiology*: generally following a fall onto outstretched arms.
- *History*: painful elbow, arm fixed by the contralateral hand.
- *Examination*: swelling, localized tenderness at the radial head (Fig. 2.30). Movement is painful, especially pronation and supination (Fig. 2.29), limited extension.
- *Diagnostics*: X-ray of the elbow in two planes (to visualize the fracture).
- *DD*: subluxation of the head of the radius.

- **Tumor disorders**

Though rare at the elbow, these disorders must be considered as a differential diagnosis, especially if unclear and in cases of therapy-resistant elbow pain.

Chondromatosis

Multiple, partly osseous, neoplasia in the joint that lie in and on the synovial membrane as well as freely in the joint.

- *Etiology*: metaplasia of the cartilage in the joint capsule. Etiology unknown. Exogenous and endogenous causes are being discussed. Occurs more frequently in the elbow after recurring trauma.
- *History*: males are more commonly affected. Mostly seen in the elbow and the knee. Severe tenderness and pain (resembling knife stabs) during movement and upon loading, impingement.
- *Examination*: swelling, flexion and extension deficit.
- *Diagnostics*: X-ray of the elbow in two planes (differential diagnosis, damage).
- *DD*: arthrosis of the elbow.

- **Neurological disorders**

Pronator Teres Syndrome

Compression neuropathy of the median nerve as it becomes trapped in its course through the pronator teres muscle at the proximal lower arm (before branching into the anterior interosseous nerve.) Relatively rare.

- *Etiology*: long external pressure onto the lower arm. Muscle hypertrophy by training. Rarely seen in indirect trauma. Neoplasia.
- *History*: radiating pain. Paresthesia in the hand. Weakness.
- *Examination*: pressure onto the flexor side in the proximal third of the lower arm causes pain, dysesthesia, and paresthesia in the thumb, the first four fingers, and the palm. If pronated against resistance, the pain and dysesthesia/paresthesia increase. One must also look for atrophy in the thumb that is not very easy to spot (Fig. 2.42). Weakened opposition of the thumb (Fig. 2.48) and flexion in the first three fingers (sign of benediction, Fig. 2.56).
- *Diagnostics*: neurological consultation (electromyograph, nerve conduction tests, new and old lesion, denervation, repair).

Interosseous Anterior Syndrome (Kiloh–Nevin Syndrome)

Lesion to the motor branch of the median nerve (interosseous anterior nerve).

- *Etiology*: compression caused by injury (e.g., supracondylar humerus fracture in children). External pressure (crutches). Muscle anomalies. Excessive load bearing.
- *History*: pain at the proximal flexion side of the lower arm, weakness when gripping.
- *Examination*: paresis in flexing the distal thumb and in the distal index finger. Disturbed pinch grip (Fig. 2.49 and 2.34, an "O" cannot be formed with the thumb and the index finger). No sensory function loss.
- *Diagnostics*: neurological consultation (electromyograph, nerve conduction tests, new and old lesion, denervation, repair).

Ulnar Nerve Entrapment

Injury of the ulnar nerve at the medial epicondyle of the humerus. Most common compression injury at the elbow.

- *Etiology*: not always clear. Microtrauma (frequent use of telephone), blunt trauma, distal humerus fracture. As a late paralysis after years following an avulsion of the ulnar epicondyle in childhood (also between 20 and 40 years hereafter, caused by reactive exostosis and fibrous changes. Ganglia, chondromatosis, infection, long periods of being bedridden (chronic compression). Sport (weight lifting, basketball). Valgus deformity of the arm.
- *History*: more common in men than in women. Mainly between the ages of 50 and 60. Can affect both arms. Hypesthesia and dysesthesia in the small fingers are often the first symptom. Radiating pain in the fourth and fifth finger is also common. Functional impairment of the hand is also seen. Late paralysis of the hand progresses very slowly.
- *Examination*: atrophy of the small muscles of the hand and hypothenar atrophy. Wasting is visible in the space between the thumb and the index finger (paresis of the interosseous and the abductor pollicis muscles). Sensory function loss at the fifth digit and the ulnar half of the fourth digit, the ulnar half of the back of the hand, and ulnar half of the palm (Fig. 2.24). Ulnar claw (Fig. 2.58). A pinch grip between the index finger and the middle finger is not possible. Positive Froment's sign (Fig. 2.35, compensatory flexion of the distal thumb when holding a piece of paper between the thumb and the proximal joint of the index finger).

- *Diagnostics*: X-ray of the elbow in two planes, tangential imaging of the ulnar sulcus. Neurological consultation (electromyograph, nerve conduction tests, new and old lesion, denervation, repair).

Supinator Syndrome

Injury to the pure motor branch of the radial nerve, the ramus profundus, at the elbow when it enters the fibrous arcades of the supinator and short radial extensor carpi muscle. The sensory branch of the radial nerve is not affected.

- *Etiology*: localized trauma. Fracture to the head of the radius or dislocation (e.g., Monteggia fracture). Indirect trauma via hyperextension of strong muscles. Tumors, localized fibrosis.
- *History*: localized pain at the head of the radius. Eventually weakness in the hand.
- *Examination*: localized tenderness to pressure distal to the radial head (Fig. 2.30). Pain during supination against resistance. Weakened extension in the wrist. Weakened extension in the fingers. Sensory function undisturbed.
- *Diagnostics*: neurological consultation (electromyograph, nerve conduction tests, new and old lesion, denervation, repair).

2.4 Hand

2.4.1 Systematic Examination

- **Local findings**

Axes/position	Physiological/pathological (right/left)	Bayonet position/radial deviation/ prominence of the ulnar styloid
		Ulnar deviation/radial deviation/swan neck deformity/Boutonnière deformity/ hammer finger
		Z-deformity (thumb)
Metric deviation	None; if present then (right/left):	Localization, plus/minus variation; gigantism/dwarfism Amputation
Swelling/redness/ hyperthermia	None; if present then (right/left):	Localization/extent/circumference/ consistency (soft/firm/movable)
Joint swelling	None; if present then: slight/clear and pain-free or painful	Localization (wrist, carpometacarpal joint, finger base, and middle joints)
Hematoma/abrasion/ open wound	None; if present, then (right/left):	Localization/extent/size
Scars	None; if present, then (right/left):	Localization/extent/consistency (soft/ firm/movable)
Fingernails	Inconspicuous; pathological: Clubbing/pitted nails/onychomycosis/ disturbed growth (right/left)	Fingers 1–2–3–4–5
Skin	Smooth/course; dry/moist, rhagade/ ulceration/callus/palmar erythema, nodules (right/left)	Palms/dorsal hand/fingers 1–2–3–4–5
Muscles	Thenar/hypothenar/interosseous space 1-2-3-4	Highly developed/wasted/shortened atrophy (significant?), muscle tone increase or decrease (right/left)
Mobility wrist	Dorsal extension/palmar flexion Pronation/supination	––/––/––Degrees (passive; right/left)

	Distance between the dorsal plane of the hand and the fingertips	--cm
Mobility fingers	Dorsal extension/palmar flexion (carpometacarpal joint, PIP, DIP joints)	––/––/––Degrees (passive; right/left)
	Maximal finger span (thumb to the fifth finger)	--cm (right/left)
	Fingertip–palm distance (Fingers 2–3–4–5)	--cm (right/left)
Finger function	Intact or possible; disturbed	Finger pinch pain (placing the first finger onto the second–fifth)/key grip/rough grip (holding a pencil)/bottle grip
Wrist pain	None; if present: positive (right/left)	Tenderness to movement or pressure at the radial/ulnar styloid process; at the carpal bones (palmar/dorsal, radial/ulnar), anatomical snuff box (scaphoid bone)/Tinel's sign (palmar wrist)/Finkelstein test
Metacarpal finger pain	None; if present then (right/left):	Mobility pain (joint)/tenderness: joint, fingertips/palm/head or base of the first to fifth metacarpal bones/thenar and hypothenar
Collateral ligaments of the fingers	Stabile/increased lateral instability (right/left; medial/lateral)	Fingers 1–2–3–4–5 (PIP, DIP joints)

- **Neurology**

Deep tendon reflexes	Biceps tendon (C5) Triceps tendon (C7) Radius periost (C6)	Vigorous/decreased/absent/supernormal (hyperreflexic) (right/left)
Sensory function examination	Dermatome (segment or nerve assignable/not exactly assignable)	Hypesthesia/paresthesia/dysesthesia (right/left)
Motoric	Elbow flexion (C5/C6) Elbow extension (C7) Pronation (C6–Th1) Supination (C5/C6) Hand diffraction (C6–Th1) Hand stretching (C6/C7) Wrist drop (radial nerve) Hand of benediction (median nerve) Ulnar claw (ulnar nerve) Finger pinch grip (D1–D2) Froment's sign	Intact/attenuated (M0–M1–M2–M3–M4–M5) (Right left)

- **Perfusion**

Arteries	Axillary artery Radial artery	Fully/barely/not palpable (right/left)
Veins	Venous stasis	None/present (right/left)
Capillary pulse	Fingertips	Visible/invisible

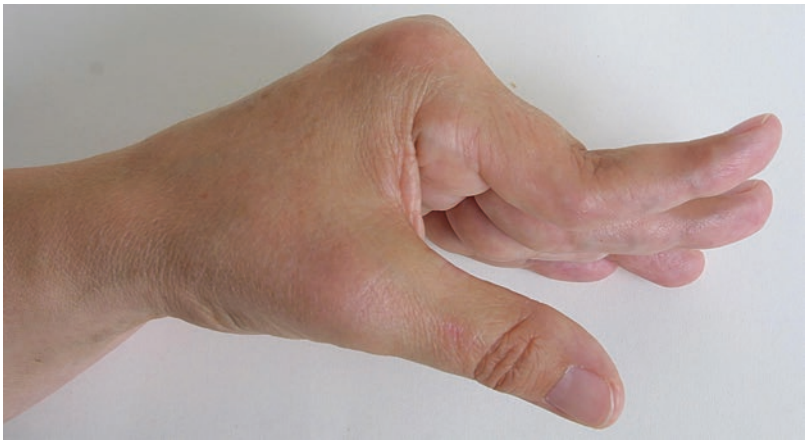


Fig. 2.36 Swan neck deformity. Involves a malposition of the long fingers. The metacarpophalangeal joint is overextended, and the distal joint is fixed in a flexed position. The carpometacarpal joints are also mostly deformed. The cause is a defect in the palm's fascia, i.e., the finger's flexor tendons at the middle joints. Common in chronic polyarthritis or following an accident

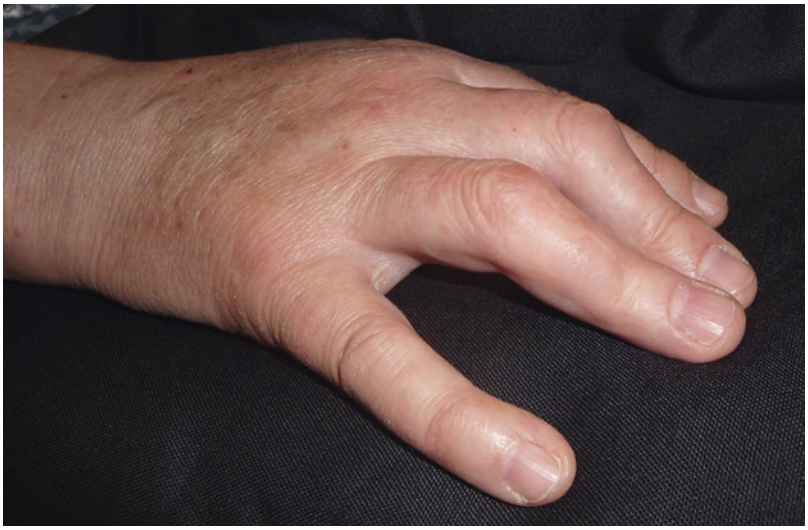


Fig. 2.37 Boutonnière deformity of the third and fourth finger (courtesy of Prof. Christoph Baerwald, University clinic Leipzig). In the Boutonnière deformity, a malposition of one of the four longer fingers of the hand is present. The middle joint is flexed and the distal joint is extended or overextended. Mostly caused by a defect of the extensors at the middle joint in rheumatic disorders or following an injury

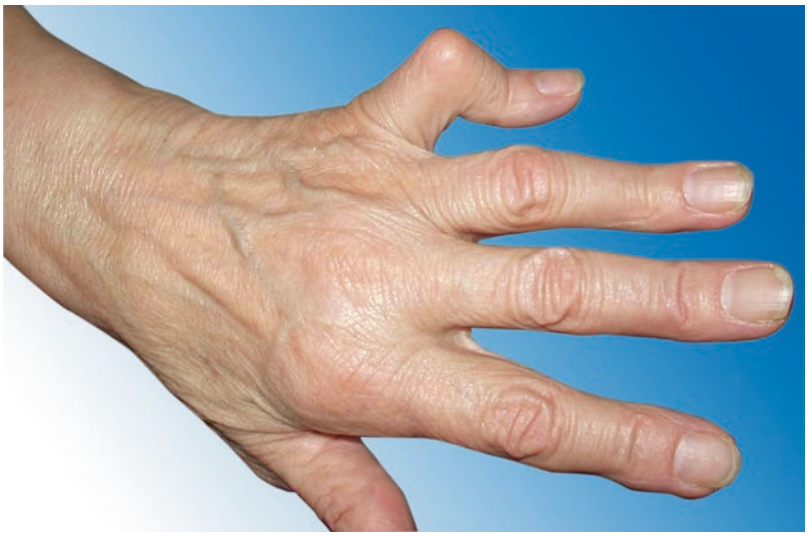


Fig. 2.38 Boutonnière deformity of the pinkie (Courtesy of Prof. Uwe Lange, University clinic Giessen/Bad Nauheim)

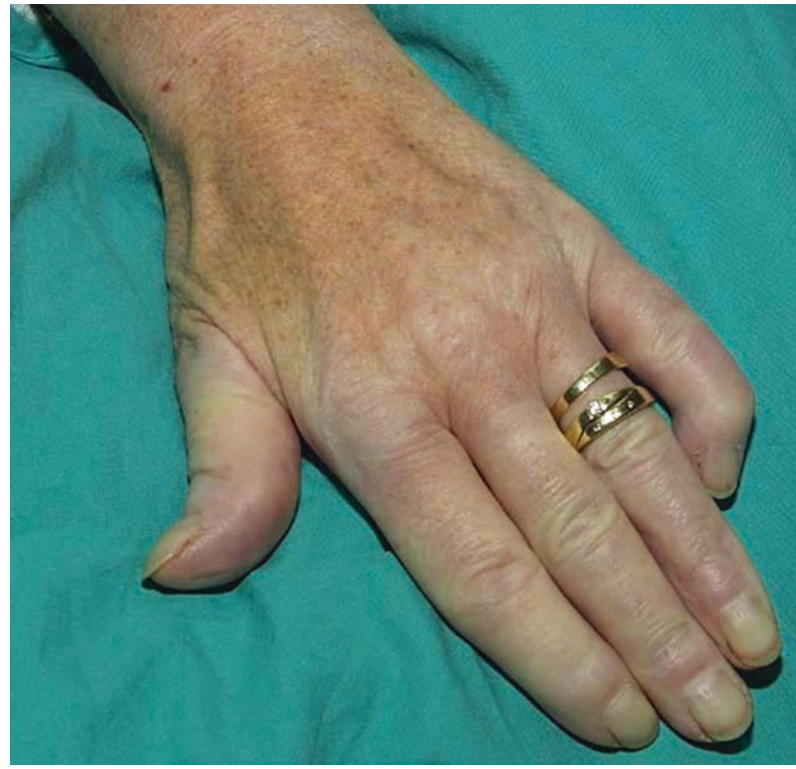


Fig. 2.39 Hammer finger DV

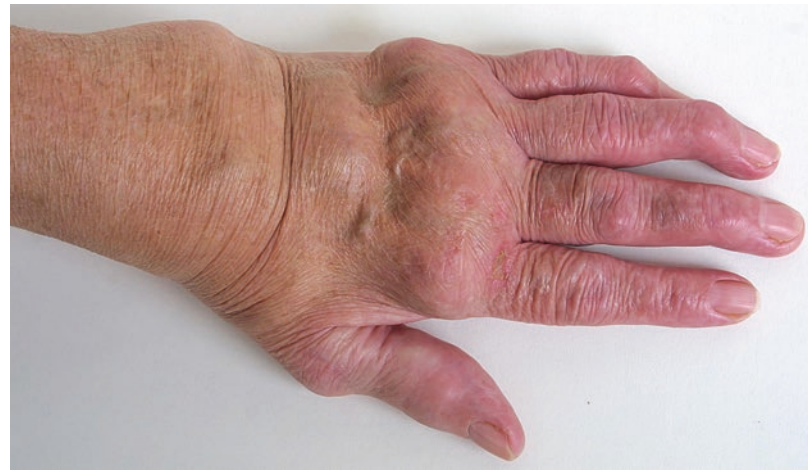


Fig. 2.40 Rheumatic hand: swelling of the MCP joints. Atrophy of the interosseous muscles. 90/90 deformity of the thumb, prominence of the styloid process of the ulna, bayonet deformity of the hand

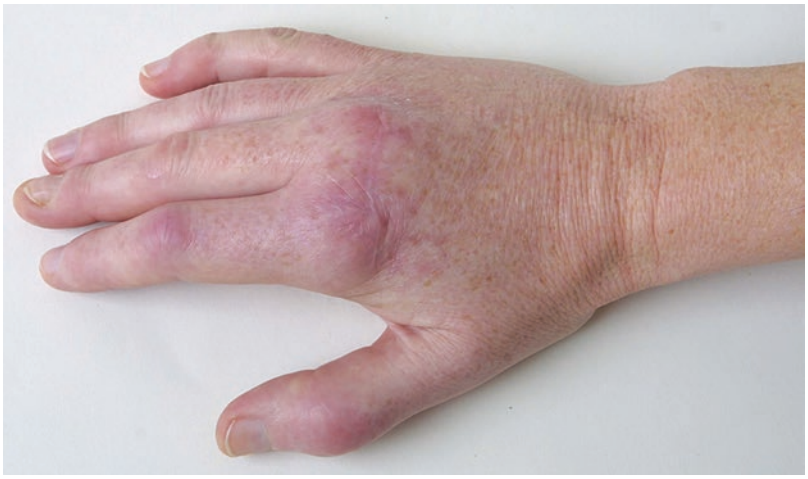


Fig. 2.41 Swelling of the PIP joints of the index and middle fingers as well as the distal joint of the thumb

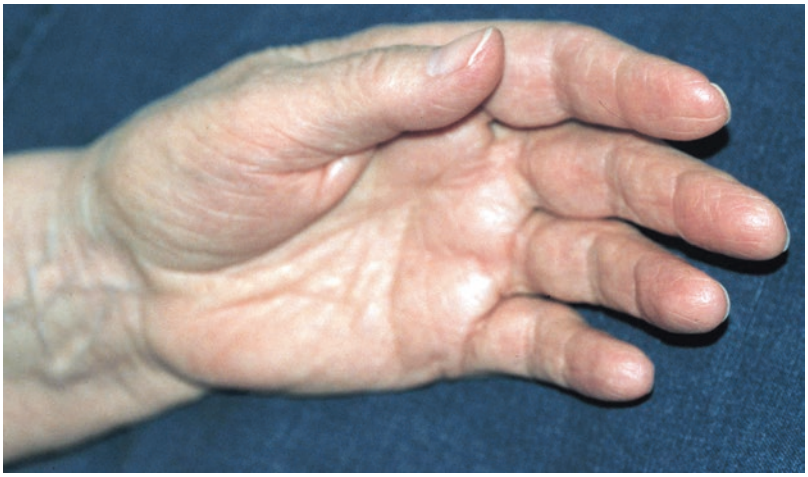


Fig. 2.42 Thenar atrophy in chronic carpal tunnel syndrome (median nerve)

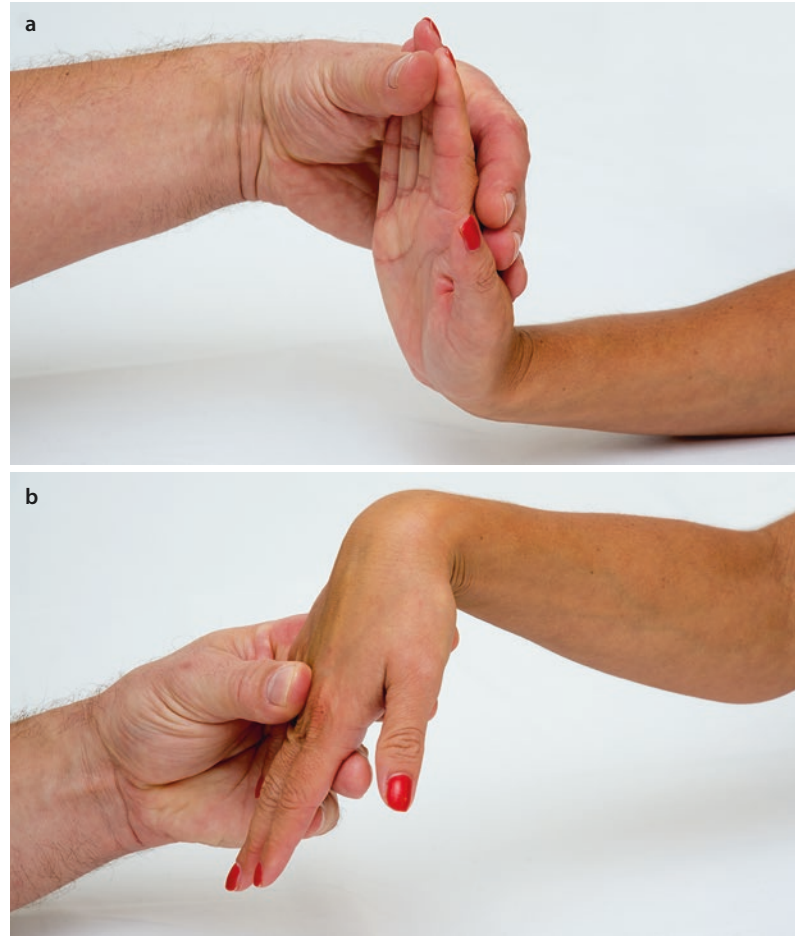


Fig. 2.43 (**a**, **b**) Testing dorsal extension/palmar flexion in the wrist. Normal ROM: 60–90/0/60–80°

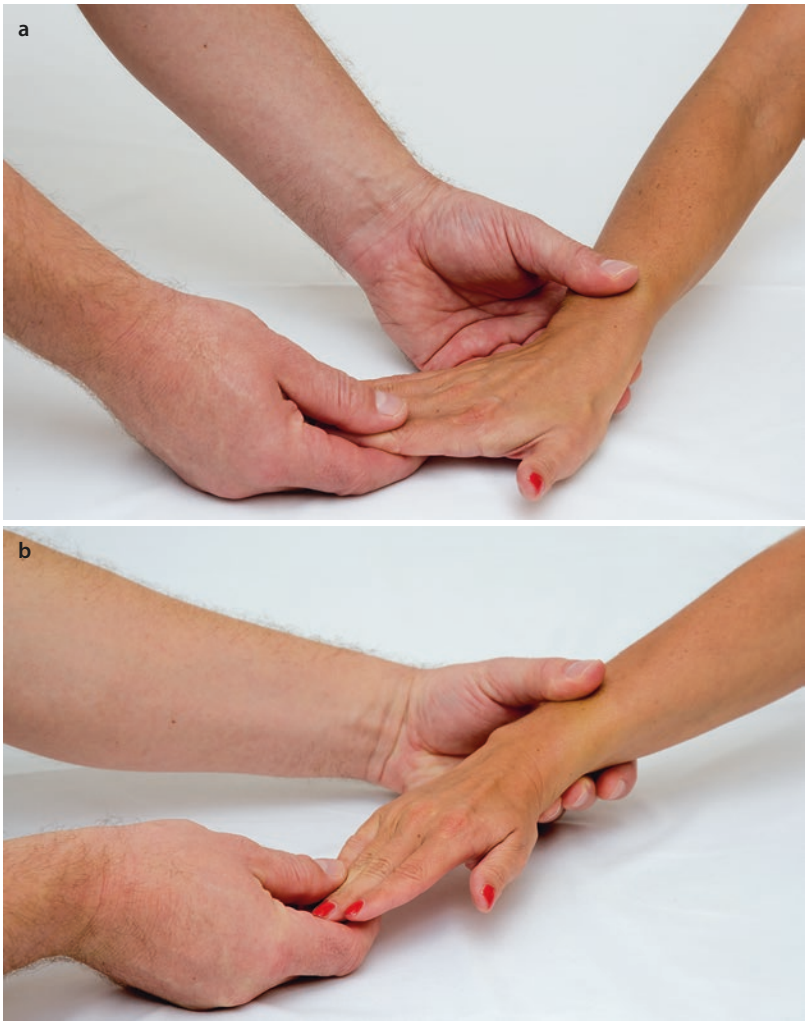


Fig. 2.44 (**a**, **b**) Testing ulnar abduction/radial abduction in the wrist. Normal ROM: 25–30/0/30–40°

Fig. 2.45 Testing the dorsal hand plane and the fingers. The patient is asked to flex the second to fifth finger in the carpometacarpal joints. The distance between the dorsal hand plane and the fingertips is measured

Fig. 2.46 Testing maximal finger span

Fig. 2.47 Testing fingertip–palm distance. Serves for testing the flexibility of the fingers

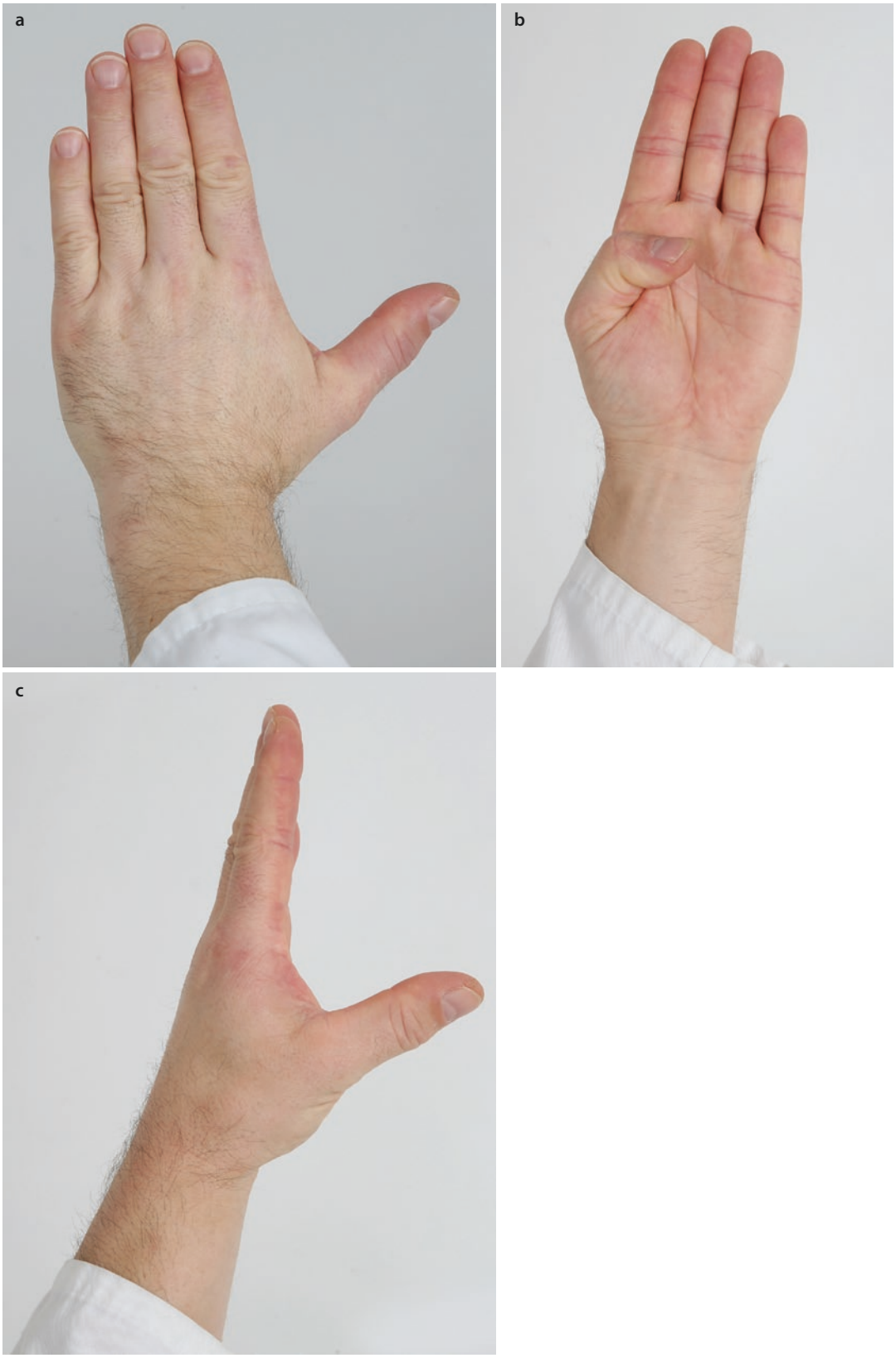


Fig. 2.48 (**a**, **b**, **c**) Testing the mobility of the thumb: abduction (**a**), adduction (**b**), opposition (**c**)

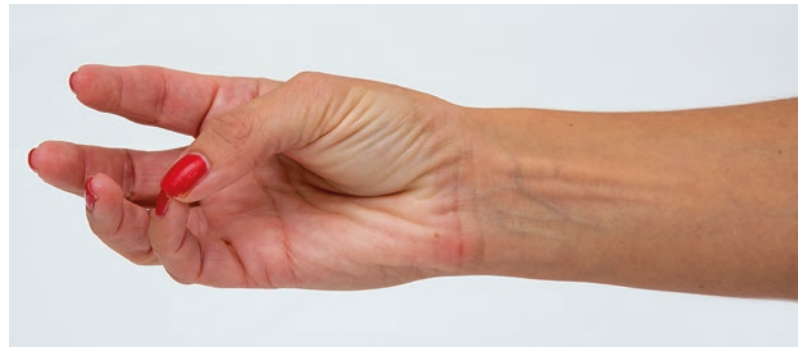


Fig. 2.49 Alternating finger tapping: the patient is asked to tap all the other fingertips with his thumb. This tests the finger function and opposition in the thumb. The opponens pollicis muscle is one of the muscles supplied by the median nerve. In median nerve lesions, the thumb opposition is not possible

Fig. 2.50 Key grip. In sensory function loss at the radial side of the index finger (radial nerve) or arthrosis of the thumb (rhizarthrosis), the key grip is not possible

Fig. 2.51 Rough grip (holding onto a pencil). This is a rough test for the gripping function of the hand

Fig. 2.52 Rough grip (holding scissors or pliers). This is a rough motor function test for the gripping function of the hand

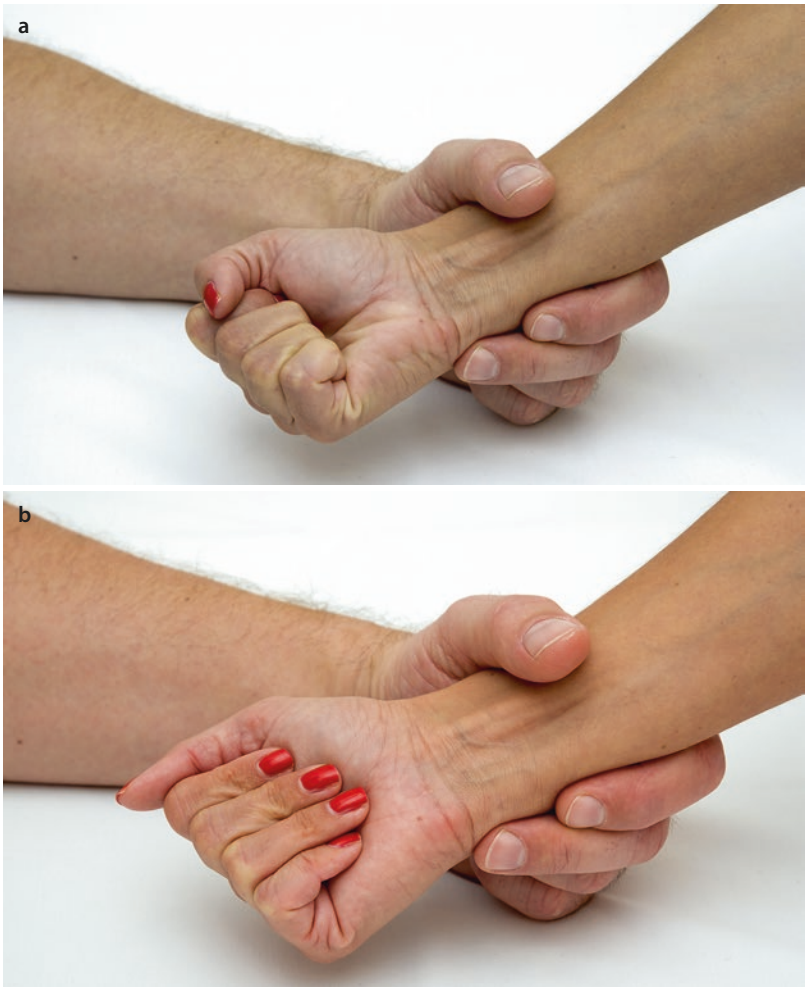


Fig. 2.53 (**a**, **b**) Forming a small (**a**) and a large (**b**) fist serves to test the ability of the fingers to flex. In the small fist (**a**), a complete flexing of the fingers in the metacarpophalangeal, the proximal and distal phalangeal joints, is possible; the fingers are placed on the flexion line of the palm. When making the big fist (**b**), the distal joints in the fingers are not flexed. Only the metacarpophalangeal and proximal phalangeal joints are flexed

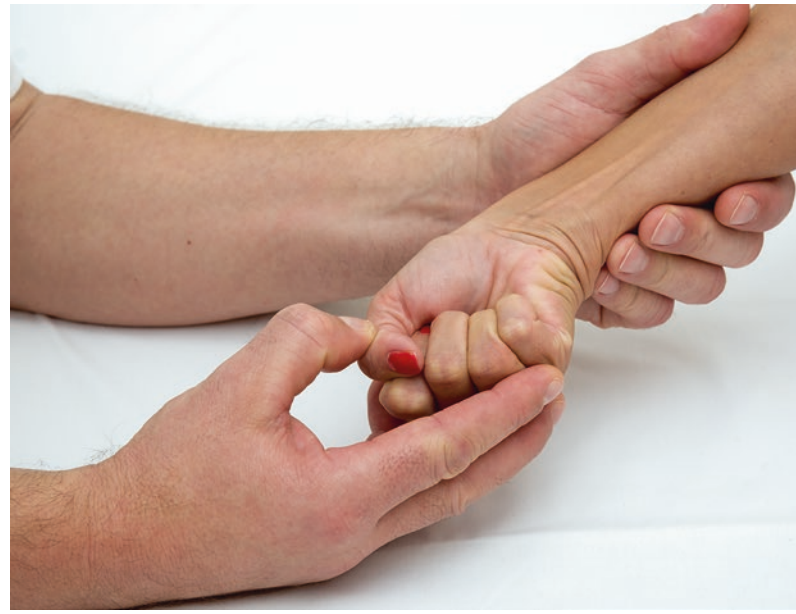


Fig. 2.54 Finkelstein sign: this test serves to diagnose de Quervain syndrome. The thumb is enclosed by the fingers and the examiner abducts the patient's hand in an ulnar direction. The patient places his thumb maximally in the palm and closes the fist. In case of stenosis in the first tendon sheath, ulnar abduction provokes pain in the thumb

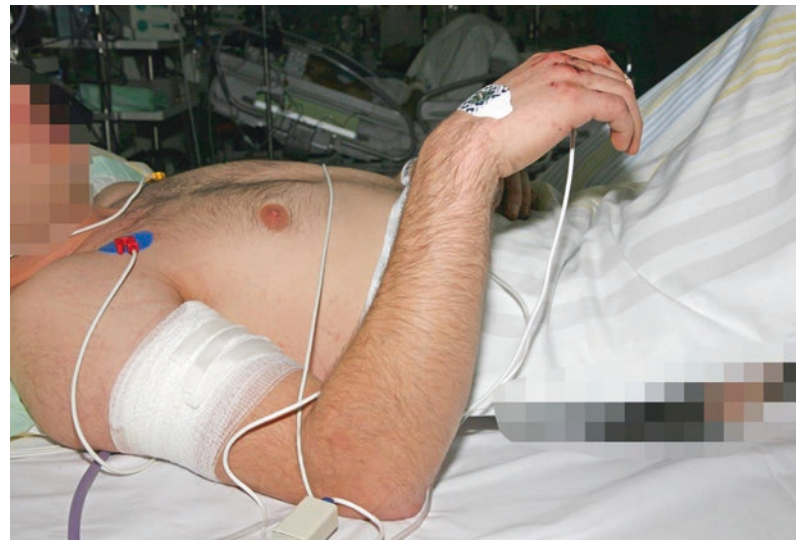


Fig. 2.55 Drop hand (radial nerve)

Fig. 2.56 Hand of benediction (median nerve)

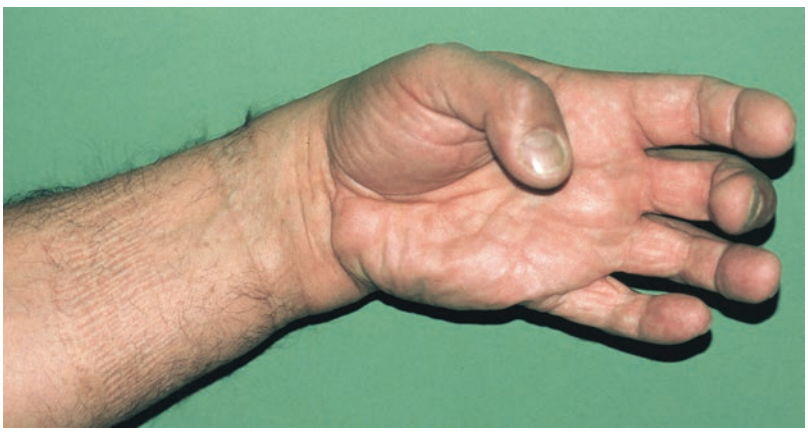


Fig. 2.57 Claw hand (ulnar nerve)

Fig. 2.58 Bottle test (median nerve): the bottle test aims at the median nerve. A bottle is gripped with the hand. Then the patient cannot abduct the thumb far enough to properly grip the bottle. The test is positive if a gap is present between the skin of the hand and the bottle when the patient grips the bottle. This occurs because the full abduction of the thumb is a function of the abductor pollicis muscle which is innervated by the median nerve

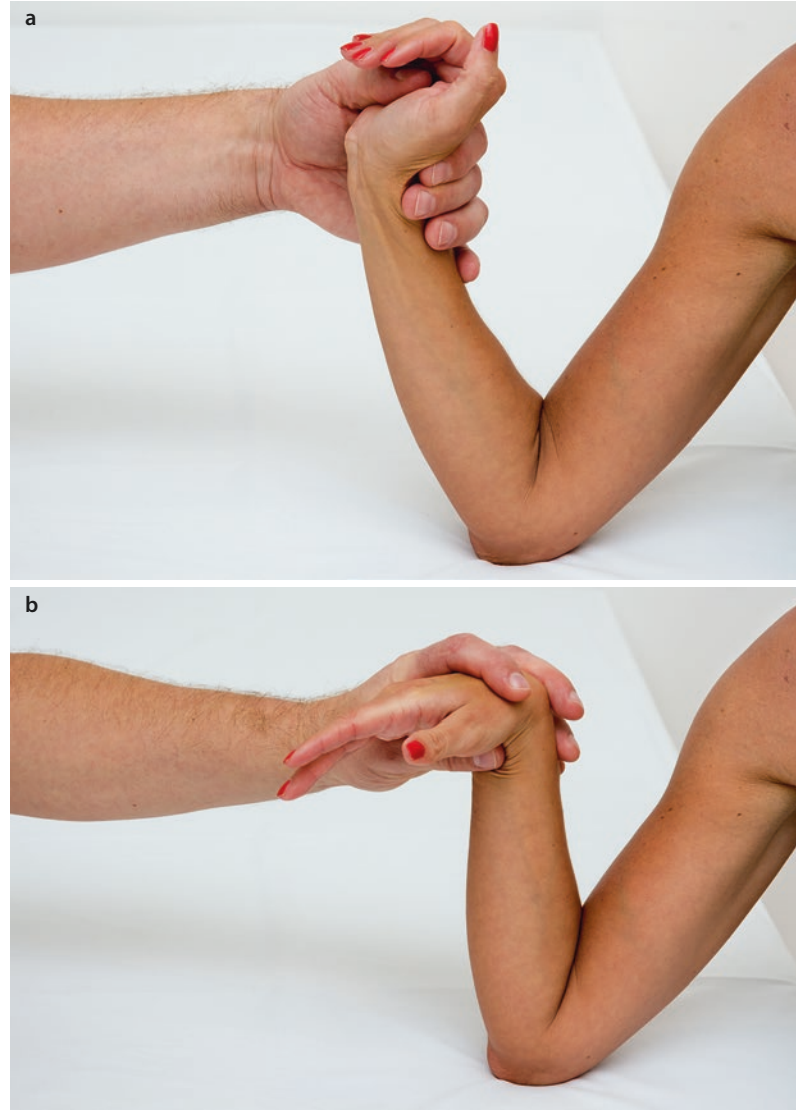


Fig. 2.59 (**a**, **b**) Testing for rupture in the flexor tendons: the wrist is passively flexed and extended. During flexion, the long fingers are extended (**a**); during extension, the long fingers are flexed (**b**). If a tendon is ruptured, the finger deviates to the dominating muscle

Fig. 2.60 Deep flexor tendons: to test the deep flexor tendons, the hand is placed on its back. The affected finger is fixed at the middle joint and the distal joint is flexed by the patient. If the flexor tendon is ruptured, flexion is not possible

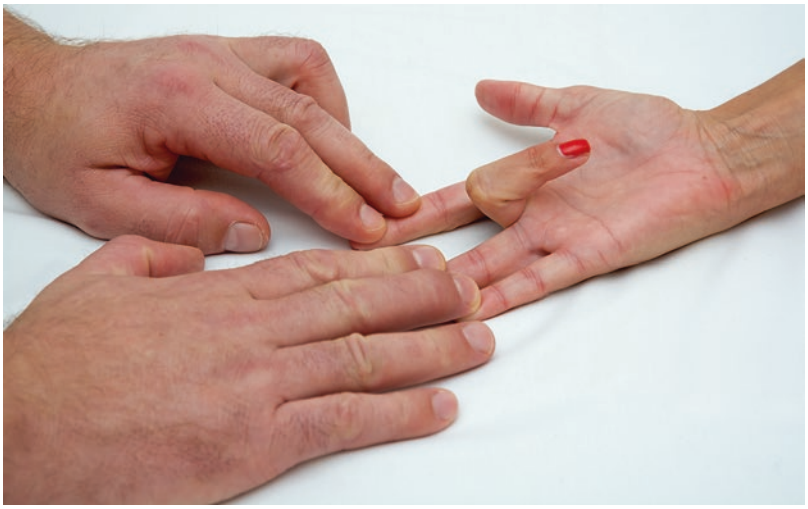


Fig. 2.61 Superficial flexor tendon: to test the superficial flexor tendons, the hand is placed on its back. The fingers that are not affected are fixed on the table, and the patient flexes the affected long finger. This leads to flexion in the middle joint, because the deep flexor tendons are immobilized by their being fixed. In case of a ruptured superficial flexor tendon, the patient will not be able to flex the finger

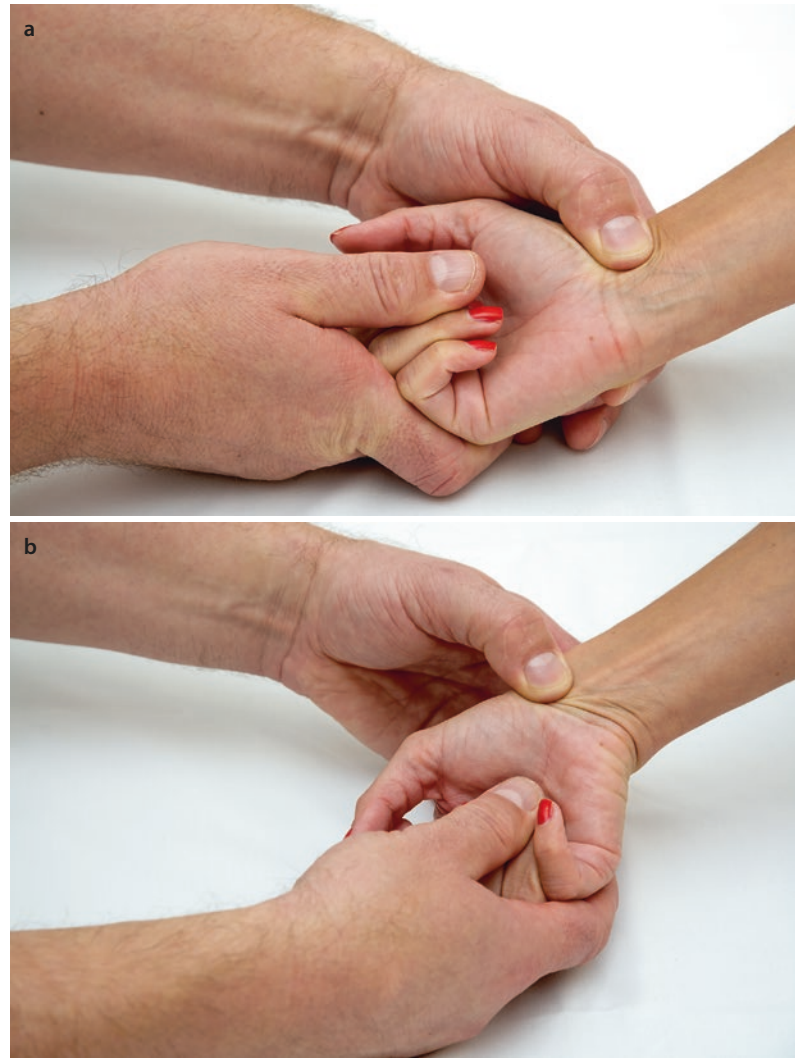


Fig. 2.62 (**a**, **b**) Watson test. The test serves to examine a scapulolunate ligament lesion. The distal scaphoid pole is palpated and pressed from the palmar side (**a**). Following this, the wrist is moved from the radial side to the ulnar side (**b**). In case the ligament is ruptured, a click phenomenon is provoked

2.4.2 Leading Symptoms of the Hand

The leading symptoms of the hand are summarized in Table 2.3.

Table 2.3 Leading symptoms of the hand

History	Pain	Local findings, functional tests	Sensory function disorder	Motor function disorder	Points to
"Snapping" of one finger when flexing or extending	Pain at the "snapping" finger	Palpable nodules on the volar side over the metacarpal heads. Localized tenderness as well as visible and palpable snapping when moving the finger	None	None	*Trigger finger*
Mostly men over 40, nodular thickening at the volar hand, increasing flexion contracture of the ulnar fingers	Barely any	Palpable nodule and strings at the volar hand. Flexion contracture of the carpometacarpal joint and/or the metacarpophalangeal joints	None	None	*Dupuytren's contracture*
Bilateral swelling at the carpometacarpal and metacarpophalangeal joints of the fingers. Morning stiffness in the affected joints	Pain when pressing the patients hand (Gaenslen sign)	In the course of disease: guttering at the interdigital spaces of the back of the hand, ulnar deviation of the fingers, swan neck deformity of the fingers, Boutonnière deformity, prominent ulnar head, bayonet hand	None	None	Beginning rheumatoid arthritis
Mostly menopausal women, small nodules at the middle and distal joints of the fingers. In the course of disease, bulbous, coarsened joints, no morning stiffness	Generally no pain in the affected joints (only during flares)	Nodules/bulbous coarsening of the middle and distal joints of the fingers. In the course of disease, radial deviation of the distal members of the fingers, ulnar deviation of the middle members of the fingers, extension deficiency, and incomplete closing of a fist	None	Paresthesia in the fingertips is possible	*Polyarthrosis*
Especially women over 50, strain-dependent pain, in the course of disease, also at rest, and at night in the radial wrist	Pain when wringing out laundry or opening a door	Localized tenderness at the carpometacarpal pollicis joint, painful mobility in the thumb; in the course of disease, abduction and extension are limited	None	None	*Rhizarthrosis*

(continued)

Table 2.3 (continued)

History	Pain	Local findings, functional tests	Sensory function disorder	Motor function disorder	Points to
Women between 40 and 50, nocturnal pain, paresthesia at the palm	Burning pain in the radial palm	Tenderness to pressure over the carpal tunnel, positive Tinel's sign	In the course of disease, thenar atrophy and positive bottle-grip test	Paresthesia at the radial palm and the three radial fingers, positive Phalen test	*Carpal tunnel syndrome*
Fall onto the outstretched hand	Pain in the wrist when moving	Maximal tenderness to pain over the volar palm	None	Paresthesia at the palm	*Lunate dislocation*
Hyperflexion of one finger during ball sports or when stuffing a sheet into a bed	Pain at the hanging distal member of the finger	Hammer finger (or thumb), localized tenderness, hematoma, mobility in the distal member passively free, cannot be actively extended	None	None	*Extensor tendon avulsion at the base of the distal phalanx*
Abduction injury of the thumb when skiing or when catching a ball (goalkeeper)	Pain at the carpometacarpal joint of the thumb during movement and a sensation of instability when gripping	Ulnar–palmar swelling over the carpometacarpal joint of the thumb. Localized tenderness, increased ulnar instability of the thumb	None	None	*Skier's thumb*
Direct injury to the palm of the hand	Rapid progressing aching pain	Swelling of the affected finger (rapidly progressing). Impairment of active and passive movement	None	None	*Tendon sheath phlegmon*
Previous trauma or operation at the upper extremity. Painful edema and swelling of the hand and the lower arm	Pain at rest and upon strain	Livid coloring, glossy, tautened skin. Pain during movement	None	None	*Sudeck's disease (acute stage I)*
Fall onto the outstretched hand in the past (overlooked scaphoid fracture)	Initially symptom-free, in the course of disease, pain upon strain and at rest in the anatomical snuff box and at the dorsal wrist	Tenderness to pressure and movement in the anatomical snuff box, compression pain at the thumb and the index finger. Dorsal extension limited by pain, Watson test positive	None	None	*Scaphoid arthrosis*
For example, patients working with compressor tools in construction	Pain in the carpal bones, strain-dependent pain, in the course of disease, also pain at rest	Eventually swelling, localized tenderness at the dorsal hand over the lunate bone, limitation of dorsal extension	None	None	*Lunate bone malacia*

2.4.3 Disorders

- **Clinical pictures**

Trigger Finger, Trigger Thumb

Sudden, sometimes painful, snapping of fingers during flexion and extension.

- *Etiology*: thickening of the sheath that surrounds the tendon and nodular thickening of the flexor tendon. Commonly seen in excessive loading or in the context of degenerative disease. Also seen in rheumatoid arthritis and following old injuries to the hand with part-severing of the tendon. Leads to stenosis of the tendon sheath. In infants, a congenital thickening of the long tendon of the thumb (pollex flexus congenitus) or the flexor tendons of the fingers.
- *History*: when flexing or extending the fingers, a painful snapping occurs. In some cases, several fingers are affected.
- *Examination*: localized tenderness to pressure at the head of the metacarpal bones. Nodules are palpable in this area that are mobilized when flexing and extending the hand. Visible snapping of the fingers during flexion and extension. In toddlers, flexion contracture of the distal thumb is found.

Tendon Dislocation

Dislocation of the tendon located over the metacarpal bone, by tearing of the fibrous cap of the extension muscle in an ulnar direction. Rare.

- *Etiology*: spontaneous or after light trauma, especially in chronic polyarthritis caused by penetrating articulo-synovitis.
- *History*: determined by the underlying rheumatic disorder.
- *Examination*: ulnar deviation of the fingers (preexisting) and an extension deficit.

Ganglion Cyst

Belongs to the tumorlike lesions of the soft tissue. Most common subcutaneous tumorlike change. Connected to the joint capsule or tendon sheath located beneath the cyst. Cystic structure containing a clear, viscous fluid (mucin, consisting largely of hyaluronic acid). Mostly dorsal to the lunate bone.

- *Etiology*: unclear. Develops from the synovial membrane of the joint capsule toward the ligaments. Occurs after excessive loading and flexion.
- *History*: three times more common in women than men. Mostly between the ages of 20 and 30. Complaints range from being symptom-free to severe load-dependent pain, in part also radiating into the upper arm. Weakness when gripping with the hand. In case of a ganglion cyst in the annular ligament, the pain is exacerbated by gripping.
- Distal to the ganglion cyst, dysesthesia and hypesthesia can occur due to nerve compression (e.g., if the ulnar nerve is affected in ulnar–palmar located ganglion cysts).
- *Examination*: described, subcutaneous swelling. Can be conspicuously visible, but also sometimes difficult to spot. Especially found at the back of the wrist when flexing. Palpable ganglion cyst of the annular ligament at the height of the first annular ligament. The consistency is often firm and elastic with a smooth surface and skin that can be mobilized.
- *Diagnostics*: X-ray in two planes if persistent (to rule out pathological changes to bone). Ultrasound (well-circumscribed borders, limited size).

De Quervain Syndrome

Painful stenosis of the first synovial sheaths of the extensor tendons of the abductor pollicis longus and the extensor pollicis brevis. Associated with a thickening of the retinaculum and an elevation of the tendons.

- *Etiology*: tenosynovitis, caused by strain (secretaries, paddling, canoeing).
- *History*: strain-dependent pain in the area of the styloid process of the radius that radiates into the thumb and the lower arm. Pain especially when gripping (e.g., wringing out a towel) and holding an object.
- *Examination*: visible and palpable swelling of the dorsoradial retinaculum. Ulnar abduction in the wrist is limited. Positive Finkelstein sign (Fig. 2.54, the patient is asked firstly to fold the thumb into the palm and secondly to subsequently make a fist: ulnar abduction is now painful).
- *Diagnostics*: X-ray of the wrist in two planes (to rule out pathological changes to bone).
- *DD*: rhizarthrosis. Styloiditis of the radius.

Kienbock's Disease

Avascular necrosis of the lunate bone. Divided into four radiological stages. Can lead to arthrosis of the hand (stage IV).

- *Etiology*: not always clear. Interruptions in blood supply by working with compression tools, by repetitive dorsal extension and compression in the wrist. Common in the minus variance of the ulna.
- *History*: strain-dependent pain in stages I and II, later also pain at rest. In the final stage, patients often report reduced pain. Uncharacteristic complaints are common.
- *Examination*: initially inconspicuous, in the course of disease, swelling over the lunate bone. Localized tenderness dorsal to the lunate bone and a limitation in dorsal extension are felt.
- *Diagnostics*: X-ray of the wrist in two planes, MRI (to visualize the damage, differential diagnosis).
- *DD*: tenosynovitis, ganglion cyst, distortion.

Scaphoid Pseudoarthrosis and Avascular Necrosis

Nonunion of the navicular bone, partly fibrous union. Divided into stable, non-displaced pseudoarthrosis; unstable, displaced, or compressed pseudoarthrosis; and pseudoarthrosis with early and with late degenerative change.

- *Etiology*: following an overlooked fracture, insufficient immobilization of the joint, severe joint dislocation, or instability. Vertical oblique fracture.
- *History*: often an incidental finding, as it is often symptom-free. Pain upon strain or in later stages at rest at the anatomical snuffbox as well as dorsal and palmar to the scaphoid. Localized swelling.
- *Examination*: localized swelling, tenderness to movement, and pressure at the anatomical snuffbox. Compression pain in the thumb and index finger. Painful limitation in wrist movement, especially dorsal extension (Fig. 2.43). Positive Watson test (fixing the scaphoid bone between the thumb and index finger, pain when moving; Fig. 2.62). Palpable instability in ulnar and radial abduction in the wrist is possible.
- *Diagnostics*: X-ray of the wrist in two planes, eventually MRI (to visualize the damage and for differential diagnosis).
- *DD*: carpometacarpal osteoarthritis.

Dupuytren's Contracture

Nodular thickening and contracture of the palmar fascia. Affects the palm first and in course the fingers. Begins with cell proliferation (nodular form) and progresses into fibrous cords (lamellar form).

- *Etiology*: not clear. Familial disposition (in about 25 %). More common in patients with diabetes and alcohol-induced liver cirrhosis. Myofibroblast theory (contracting influence of these cells). Collagen type III dominates. Furthermore, fibrous tumors or primary fibrositis. The neurogenic theory links the disorder to discrete lesions of the ulnar nerve.
- *History*: mostly men under 40. In 65 % of cases, both hands are affected. Most commonly seen in the ring finger, in later stages, also the pinkie and the middle finger. At the beginning, a thickening and shrinkage of the palmar aponeurosis with increasing flexion contracture of the fingers, limiting mobility. Nodules can also be seen. Presents in flares over several years. Pain is rare.
- *Examination*: cutaneous retraction and palpable nodules and later fibrous cords in the palm (almost exclusively affecting the ulnar fingers). In advanced stages, flexion contracture of the base and middle joints, and in some cases, Boutonniere deformity. Extension limitation of the finger. In 50 % of cases, there is thickening over the knuckles ("knuckle pads").
- *Diagnostics*: X-ray of the hand in two planes (to visualize all the joints in the hand).
- *DD*: scar tissue following injury.

Complex Regional Pain Syndrome (Sudeck's Atrophy/Algoneurodystrophy)

Painful dystrophy of the extremities with regionally disturbed blood supply and atrophy of the soft tissue and bone.

- *Etiology*: following fractures or operations. Localized inflammation with, among others, psychological involvement. Idiopathic in 20 % of cases.
- Type I: Sudeck's atrophy or algoneurodystrophy (trauma, no demonstrable nerve lesions).
- Type II: causalgia (trauma, evidence of obvious nerve damage).
- *History*:
  Acute stage I: inflammatory stage with hyperemia. Edemalike swelling of the skin, pain at rest and under strain.

Subacute stage II: dystrophic stage. Sets in after 2–4 months. The swelling recedes; the subcutaneous atrophies. The joint capsule and the ligaments shrink.

Chronic stage III (*end stage*): atrophy stage. Sets in after 3–6 months. Atrophy of the skin, the subcutaneous, and the skeletal bones including severe movement impairment and contracture.

- *Examination*:

Acute stage I: hand and lower arms are swollen; the skin is livid, glossy, and warm. The skin appears tautened. Pain at rest and during movement.

Subacute stage II: swelling at the extremities is reduced. Pale, cool, glossy skin. Mobility is limited or completely lost.

Chronic stage III (*end stage*): in comparison to the opposite side, clear atrophy of the extremity. Reduced range of motion and contracture in the elbow and finger joints. Reduced strength and disturbed gripping function in the hand (◘ Figs. 2.45, 2.46, 2.50, 2.51, 2.52, and 2.53).

- *Diagnostics*: X-ray of the lower arm and the hand in two planes (demineralization). Blood tests (cross-links in urine are elevated).

- **Congenital malformation and metabolic disorders**

■ *Syndactyly*

Partial, subtotal, or complete fusion of two or more fingers. Most common malformation in the hand. Cutaneous, osseous, and complex syndactylies are distinguished. In complex syndactyly, more malformations are present.

- Etiology: presents in the scope of several syndromes as a facultative or obligatory feature. Mostly autosomal dominant. Also sporadic.
- *History*: more common in boys than girls. Mostly seen in the middle and ring finger. Fingers can be partly separated or completely fused. The fingers can be connected only via soft tissue (cutaneous syndactyly) or bones (mostly only the distal phalanx, *osseous syndactyly*). *Complex* syndactyly: combination with other malformations.
- *Examination*: partial, subtotal, or total (i.e., reaching up to the distal phalanx) fusion of the fingers. Mostly affects a singular interdigital space. In some cases, the fingernails are also fused. Flexion and extension are barely limited. In complex syndactyly, one finds, e.g., malformed fingers, ankylosis, spoon hand deformity, spade hand deformity, and changes to the osseous skull among others.
- *Diagnostics*: X-ray of the hand in two planes (to visualize the bones).

■ *Polydactyly/Oligodactyly*

Numerical deviation of the fingers—either presenting with more or less than five fingers per hand.

- *Etiology*: more common in patients of African heritage. Also common in several malformation syndromes.
- *Examination*: radial polydactyly (double thumb), central polydactyly (doubling of the second, third, or fourth digit, also larger numbers), ulnar polydactyly (doubling of the little finger). Mirror hand deformity: complete or incomplete doubling of the hand. Hypoplasia and aplasia of the thumb.
- *Diagnostics*: X-ray of the hand in two planes (to visualize the bones).

■ *Metric Variations*

Brachydactyly (*shortening of the skeletal bone of the finger*). *Triphalangia of the thumb and hyperphalangia* (*abnormal transverse segmentation of the phalanges*).

- **Degenerative disorders**

■ *Carpometacarpal Osteoarthritis*

Osteoarthritis at the base of the thumb (*the first carpometacarpal joint*).

- *Etiology*: idiopathic. Often in connection with polyarthrosis (arthrosis of the finger joints). In rare cases, secondarily following Bennett's or Rolando's fracture.
- *History*: seen in about 10 % of the population. Mostly in women over 50. Almost always affects both hands. Early symptoms include strain-dependent pain, especially when gripping (e.g., wringing out laundry, unlocking a door). In the course of disease, pain at rest and at night, radiating distally and proximally. Increasing impairment of mobility.
- *Examination*: dorsal, firm swelling over the base of the thumb. Localized tenderness to pressure, painful during movement, and crepitation. In the course of disease, adduction contracture with a limitation in the abduction of

the thumb (Fig. 2.48) and overextension in the carpometacarpal joint.
- *Diagnostics*: X-ray of the hand in two planes (to visualize damage to the joint, for differential diagnosis).
- *DD*: scaphoid pseudoarthrosis, de Quervain syndrome.

Polyarthrosis

Arthrosis limited to the finger joints. Arthrosis in the distal joints is known as Heberden's arthrosis. Arthrosis of the middle joints should be clearly differentiated from Bouchard's nodules. Mostly presents in combination with carpometacarpal osteoarthritis.
- *Etiology*: the primary cause is unknown. Hormonal and endocrine influences are being discussed as well as neurovascular influences. Dominant inheritance pattern in women and recessive pattern in men.
- *History*: common in menopausal women. Symptoms are very light. Morning stiffness does not occur. Initially small nodules dorsally, medially, and laterally over the interphalangeal joints—mostly presenting over the distal joints (Bouchard's nodules). In the course of disease, osteophytes develop, sensory function is reduced, and paresthesia occurs. Inflammatory flares do occur. Deviation of the axis and limitation in mobility are common. Functionality, however, is hardly impaired.
- *Examination*: visible and palpable nodes in the joints of both hands. In the course of disease, bulbous, coarsened joints. No tenderness. In inflammatory flares, redness and tenderness to pressure, including pain during movement. In progressed disease, radial deviation of the distal phalanges and ulnar deviation of the intermediate phalanges. Limited extension and limited flexion. Incomplete closing of the fist. The distance between the fingertips and the palm is increased (Fig. 2.47). Paresthesia of the fingertips is possible. Muscle strength is reduced when closing the fist.
- *Diagnostics*: X-ray of the hand in two planes (only if the patient has complaints, to check for damage to the joints).
- *DD*: beginning chronic polyarthritis (swelling at the carpometacarpal joints).

Inflammatory Disorders

Paronychia

Purulent infection of the soft tissue surrounding the fingernails.

Boils

Purulent infection at the extension side of the fingers.

Panaritium

Panaritium is a special form of phlegmon. Usually describes a circumscribed purulent infection at the finger. The transitions can be fluent, e.g., when ***Panaritium subcutaneum*** *spreads and infects the tendon sheath (then Panaritium tendinosum). Superficial (Panaritium cutaneum, subcutaneum, subunguale) are distinguished from deep panaritia (Panaritium tendinosum, ossale, articulare).*
- *Etiology*: mostly staphylococcal infections, rarely also streptococcus. Secondarily also mixed infections. In some cases, viral infections (herpes), fungal infections, or infections involving *Mycobacterium tuberculosis*.

Subcutaneous panaritium

Most common bacterial infection of the soft tissue of the finger.
- *Etiology*: often spontaneous, also following work performed without adequate protection of the hands.
- *History*: swollen, reddened, oversensitive, and painful fingertips. Mostly in the distal member but also in the intermediate member.
- *Examination*: localized swelling, reddening, hyperthermia. Tenderness to pressure and touch. Pain during movement.
- *DD*: tuberculosis of the skin.

Osseous panaritium

Bacterial infection of the bones at the finger. Often spreads to the distal joints and the head of the intermediate member.
- *Etiology*: primarily via a localized injury or spreading from the environment (e.g., as subcutaneous panaritium).
- *History*: pain, reddening, and swelling. Mostly in the distal member. Later spontaneous ankylosis of the distal joints.
- *Examination*: localized swelling, reddening, hyperthermia of the skin. Tenderness, pain during movement.
- *Diagnostics*: X-ray of the hand in two planes (looking at the local and surrounding bones

and joints). Blood tests (erythrocyte sedimentation rate, leukocytes, CRP).

Articular panaritium

Bacterial infection of the joints in the finger. Corresponds to septic arthritis.

- *Etiology*: primarily via direct injury (e.g., bite wound) or as a spreading infection from the environment (e.g., as osseous panaritium of the distal member). In rare cases, metastatic.
- *History*: severe pain, especially during movement, severe reddening, and swelling of the joint. Leads to spontaneous ankylosis if not treated.
- *Examination*: localized swelling, reddening, and hyperthermia over the joint. Flexion position of the fingers. Localized tenderness to touch and pressure, mobility severely reduced due to pain, and traction and compression of the finger are painful.
- *Diagnostics*: X-ray of the hand in two planes (looking at the local and surrounding bones and joints). Blood tests (erythrocyte sedimentation rate, leukocytes, CRP).

Interdigital phlegmon

Bacterial infection of the interdigital space.

- *Etiology*: often spontaneous but can also present following work in unsterile environments without adequate hand protection.
- *History*: severe pain, redness, and swelling in the interdigital space.
- *Examination*: localized swelling, redness, and hyperthermia of the skin. Severe tenderness, pain during flexion and extension of the fingers.
- *Diagnostics*: X-ray of the hand in two planes (looking at the local and surrounding bones and joints). Blood tests (erythrocyte sedimentation rate, leukocytes, CRP clearly elevated).

Tendon sheath phlegmon

The flexor tendons are affected in panaritium tendinosum (tendon sheath phlegmon). A special form is the "V-phlegmon," which involves an infection of the communicating tendon sheaths of the pinkie and the thumb.

- *Etiology*: direct injury to the tendon sheath or indirect spreading of infection.
- *History*: rapidly exacerbating, mostly throbbing pain during rest and when moving. Rapid swelling of the finger (within hours!). Fever.
- *Examination*: swelling, redness, and hyperthermia of the finger or fingers (the pinkie and thumb in "V-phlegmon"). Fingers are fixed in a half-flexed position. Severe tenderness. Flexion and extension of the finger or fingers are limited.

The disorder develops quickly, within a few hours. If undetected, it rapidly leads to necrosis of the affected tendon.

- *Diagnostics*: X-ray of the hand in two planes (visualizing the local and surrounding bones and joints). Blood tests (erythrocyte sedimentation rate, leukocytes, CRP severely elevated).

Phlegmon of the palm

Bacterial infection above or below the fascia of the palm, the thenar, and the hypothenar.

- *Etiology*: mostly spreading from an abscess in the palm or from tendon sheath phlegmon. Commonly also via an injury to the thumb.
- *History*: rapidly increasing, throbbing pain. Pain at rest and during movement. Painful reduction of movement. Malposition of the fingers. Severe reduction in the medical state of a patient, fever.
- *Examination*: redness, swelling over the back of the hand. Tenderness over the palm of the hand. The position of the fingers is typical: Extension in the proximal joints and flexion in the intermediate and distal joints of the fingers. The thenar eminence is swollen, reddened, and tender. The thumb is extended. Finger mobility is painfully limited.

Phlegmon of the palm can spread to the lower arm. The disorder is potentially life-threatening!

- *Diagnostics*: X-ray of the hand in two planes (visualizing the bones and joints). Blood tests (erythrocyte sedimentation rate, leukocytes, CRP highly elevated).

■ Specific Infections

In the hand as a specific inflammation of the skin, the tendon sheaths, the bones, and the joints.

Tuberculosis of the skin

In the hand, tuberculosis is an important differential diagnosis to furuncle in the extensor side of the fingers.

- *Etiology*: pathogen mostly *Mycobacterium bovis*. Localized infection.

- *History*: commonly seen in farmers, butchers, veterinarians, pathologists, and lab assistants. Swelling and vesicles are seen at site of the injury.
- *Examination*: localized, firm nodules under the skin. In the course of disease, vesicles will present, followed by hyperkeratotic eczema that subsides from the center of the lesion and is associated with skin atrophy.
- *Diagnostics*: excision and histology. Tine test.

Tuberculous tenosynovitis

One distinguishes between the exudative (effusion, rice bodies—corpora oryzoides—and some thickening of the tendon sheath) and the proliferative (caseating) form.

- *Etiology*: localized infection.
- *History*: swelling, redness, as well as pain in the hand.
- *Examination*: swelling under the skin around the tendon sheath. Pain during movement and when flexing or extending the fingers.
- *Diagnostics*: excision and histology. Tine test.
- *DD*: rheumatoid tenosynovitis.

Tuberculosis of the bones and joints

Presents as spina ventosa in the phalanges. Can lead to destruction of the wrist joint if the carpal bones are involved.

- *Etiology*: mostly hematogenous spreading or arising from tuberculous tenosynovitis.
- *History*: can be seen in children under 5. Unclear pain in the fingers. Rarely presents as tuberculosis of the wrist.
- *Examination*: uncharacteristic.
- *Diagnostics*: X-ray of the hand in two planes (spina ventosa shows typical spindly thickening of the bone. The bone is surrounded by several periosteal sheaths). Blood tests (erythrocyte sedimentation rate, leukocytes, CRP). Biopsy at the wrist. Tine test. Skeletal scintigraphy (accumulation increased). Gastroscopy (acid-fast bacilli).

■ Rheumatic Disorders

The rheumatic hand

Rheumatoid arthritis is a chronic and mostly progressive systemic disease of the connective tissue. It manifests with destructive changes to the joints and can also affect other organs. The hands are typically affected by rheumatoid arthritis.

- *Etiology*: unknown.
- *History*: in the *prodromal stage,* symptoms are commonly uncharacteristic. Generalized fatigue and subjective feeling of being ill, night sweats at the palms. Loss of appetite. Short-term swelling of the joints and pain upon moving the hand are possible. *Stage I* often presents with bilateral swelling of the metacarpophalangeal (MCP) and the proximal interphalangeal (PIP) joints, in the course of disease also affecting other joints. Functionality of the hand and other joints is increasingly impaired.
- *Examination*: the hand.
  Stage I: swelling of the MCP and PIP joints (Fig. 2.41). Tenderness to pressure and tenderness to pressing the hand of the patient as in a handshake (Gaenslen sign).
  Stage 2: elastic, pain-free thickening of the extensor tendons at the back of the hand (patients can present with snapping fingers and ruptured tendons). Guttering at the back of the hand (atrophy of the interosseous muscles).
  Stages 3 and 4: ulnar deviation of the fingers, Boutonnière and/or swan neck deformity (Figs. 2.36, 2.37, and 2.38), Z-deformity of the thumb, dorsal dislocation of the head of the ulna, and bayonet deformity of the hand (Fig. 2.40).
- *Diagnostics*: X-ray of the hand in two planes (joint damage is classified according Larsen in stages 1–4. In the advanced stage, one finds joint destruction, diffuse osteoporosis, and erosions).
- *Differential diagnosis*: at the beginning, polyarthrosis (starts at the proximal and distal interphalangeal joints).

- **Traumatic disorders**

■ Extensor Tendon Injury

Extensor tendon avulsion at the base of the distal phalanx.

Avulsion of the extensor tendon at the distal member base, in part with osseous fragments. Most common extensor tendon injury.

- *Etiology*: mostly by direct trauma (hard blow to the fingers). Also caused by hyperflexion of the extended fingers. Making beds (when the sheets are stuffed under the mattress) and during sports (e.g., basketball, volleyball, and other ball sports).

- *History*: commonly affects the ring and middle finger. Pain at the hanging distal finger.
- *Examination*: hammer finger or mallet finger (Fig. 2.39) or hammer thumb. Localized swelling, hematoma, and localized tenderness. Passive movement in the distal member of the finger is free, but the finger cannot be extended freely.
- *Diagnostics*: X-ray of the affected fingers (to rule out injury to the bones).

Extensor tendon injury at the proximal interphalangeal joint (*PIP*)

Injury to the central part of the extensor tendon at the base of the intermediate phalanx.

- *Etiology*: direct trauma. Preceding dislocation of the PIP joint. Spontaneous or following minimal trauma in chronic polyarthritis.
- *History*: weakness and loss of function. Often only presents 6 weeks after the initial injury.
- *Examination*: localized tenderness (especially in new injuries). Pain and reduced power in extension against resistance. Boutonniere deformity (Figs. 2.37 and 2.38), if the central part of the extensor tendon is ruptured, common with rheumatic disorders.
- *Diagnostics*: X-ray of the affected fingers (rule out injury to the bone).

Extensor tendon injury at the wrist

Rupture of the extensor tendons at the wrist in the extensor tendon sheaths.

- *Etiology*: severe tenosynovitis in the context of chronic polyarthritis.
- *History*: patients mostly complain of severe chronic swelling at the back of the hand that responded well to medication. Because of the connection between the extensor tendons via the connexus intertendineus, the functional loss is barely noticed initially.
- *Examination*: extension deficit in the hand (not severe).

Flexor tendon injury

Severing of a superficial or deep flexor tendon of the long fingers, at the thumb the tendon of the flexor pollicis longus muscle.

- *Etiology*: smooth cut injury. Jagged cuts or tears, e.g., chain saw injury. Tenosynovitis in chronic polyarthritis. Arrosion via osteophytes in carpometacarpal osteoarthritis at the thumb. Sudden extending force against the flexed finger.
- *History*: in some cases, patients report skin lesions. Cuts are often very small! Functional impairment in the hand.
- *Examination*: in some cases, skin lesion and hematoma. Localized tenderness. *Injury to the deep tendons*: active flexion in the distal joint not possible (the finger is stretched and fixed in the intermediate interphalangeal joint) (Figs. 2.59 and 2.60). *Injury to the superficial tendons*: active flexion in the intermediate joint not possible (neighboring fingers are fixed in an extended position) (Figs. 2.59 and 2.61). In part-rupture, weakness and pain when flexing against resistance. Testing functionality is difficult in children. Sensory loss distal to the wound or absent pain during active or passive movement indicated nerve injury.
- *Diagnostics*: X-ray of the affected fingers (to rule out injury to the bone).

Bennett's fracture and Rolando fracture

Bennett's fracture: *Intra-articular subluxation fracture at the base of the metacarpal bone of the thumb* (*one fragment*). *Should be differentiated from a simple fracture of the first metacarpal bone*! *Rolando fracture*: *T- or Y-shaped fracture at the base of the first metacarpal bone* (*multiple fragments*).

- *Etiology*: direct fall onto outstretched thumb with axial compression.
- *History*: severe pain in the carpometacarpal joint of the thumb, swelling, and functional impairment.
- *Examination*: localized swelling at the carpometacarpal joint. The thumb is fixed in a slightly abducted position. Tenderness to pressure and movement and painful reduction of movement.
- *Diagnostics*: X-ray of the carpometacarpal joint in two planes (to visualize the fracture and for differential diagnosis).
- *DD*: carpometacarpal osteoarthritis.

Gamekeeper's thumb (*Skier's thumb*)

Tear of the ulnar collateral ligament of the metacarpophalangeal joint of the thumb (*MCP*).

- *Etiology*: about 10 % of all ski injuries. In goalkeepers injury occurs via the attempt to catch the ball or stop its trajectory.
- *History*: pain during movement and when gripping. Instability.
- *Examination*: ulnar–palmar swelling at the joint. Localized tenderness and pain during

movement, and when checking for radial laxity, the joint will show ulnar laxity when flexed (compared to the contralateral side!) Severe swelling and reddening in chronic instability.
- *Diagnostics*: X-ray of the thumb in two planes (to visualize the fracture, differential diagnosis).
- *DD*. arthrosis. Inflammation.

Scaphoid fracture

Fracture of the scaphoid bone. Most common fracture in the wrist. Fracture can occur in the proximal, middle (most common), or distal third of the bone. The fracture can be horizontal, oblique, or vertical and either dislocated or not.
- *Etiology*: fall onto outstretched hand. The wrist is overextended and rotated.
- *History*: pain and swelling in the radial part of the wrist.
- *Examination*: swelling of the wrist (especially radial). Waning of the anatomical snuff box and in the ventral region of the radial wrist. Tenderness to compression in the thumb and index finger and painful impairment of movement in the wrist.
- *Diagnostics*: X-ray of the wrist in two planes and of the scaphoid (to visualize the fracture). If unclear, do control imaging after 1 week. In some cases, scintigraphy might be useful (increased accumulation in fractures).

Lunate dislocation

Dislocation of the lunate bone. Probably the most important dislocation in the wrist. Not common, but important as it can easily be overlooked. Can lead to aseptic necrosis of the lunate bone and to arthrosis of the wrist. In some cases, associated with median nerve injury.
- *Etiology*: almost always due to falling onto the outstretched hand.
- *History*: dysesthesia at the palm. Very similar to carpal tunnel syndrome! Ask for trauma in the patient history.
- *Examination*: relatively typical is a point of maximum pain at the palm.
- *Diagnostics*: X-ray of the wrist in two planes (to visualize dislocation).
- *DD*: peri-ulnar dislocation.

Fractures of the metacarpal bones and fingers

Fractures of the metacarpal head, neck, shaft, and base. Fractures of the proximal, intermediate, or distal phalanx. Fractures can be oblique, horizontal, spiral, or comminuted. Also either extra- or intra-articular.
- *Etiology*: mostly direct blow (with a balled fist or hitting over the hand) or a fall. Moreover, open wounds (e.g., bite wounds) or crush injuries.
- *History*: pain, swelling, and deformity. Functional loss and in some cases injury to the skin and soft tissue.
- *Examination*: localized swelling and hematoma. In some cases bites, cuts, and crush injuries. Shortening of the axis, rotation deviation becomes visible when the hand is partly closed via the position of the fingernails. Localized tenderness. Fractures to the metacarpal neck can often be palpated. Pain upon movement.
- *Diagnostics*: X-ray of the hand (to visualize the fracture).

- **Malignant disorders**

■ *Primary Tumors*

Solitary enchondroma

Most common benign tumor of the hand. The bones of the hand are the most common localization of the solitary enchondroma. Mostly in the metaphysis and diaphysis, especially in the proximal phalanx. Less common in the intermediate phalanx and in the metacarpal bones. Most commonly caused by a pathological fracture of the hand. Often an incidental finding.
- *History*: pain only in pathological fractures. Sometimes swelling can be present.
- *Examination*: sometimes presents with localized tenderness and firm swelling. Mostly no limitation to mobility.
- *Diagnostics*: X-ray of the hand in two planes, eventually MRI (localization and size of the tumor). Scintigraphy (to determine the activity of the tumor).

- **Neurological disorders**

■ *Carpal Tunnel Syndrome*

Injury to the median nerve in the carpal tunnel. Sensory function disturbance and, in some cases, disturbed motor function. Most common nerve compression syndrome.
- *Etiology*: mostly idiopathic. Stenosis of the canal from outside (peri-ulnar dislocation, bone tumor). Increase in the contents of the tunnel (tenosynovitis in rheumatic disorders, tuberculosis). Acute trauma (e.g., thrombosis

of the median artery, Colles fracture). Other: post-traumatic, scars, tumors of the nerves, hemodialysis, following burns or freezing, obesity, hormonal changes (myxedema, pregnancy, hyperthyroidism), lymphedema after breast cancer surgery, and neuropathy (especially if history of diabetes).

- *History*: more common in women between 40 and 50. More common on the right side, in 50 % of cases bilateral. Burning pain that radiates into the shoulder is typical. Nocturnal, painful paresthesia at the radial palm and in the fingertips of the radial three fingers (brachialgia paraesthetica nocturna). Patients wake up to this pain and often report shaking the hand, rubbing it, or running cold water over it to mitigate the pain. The hand becomes weak and clumsy.
- *Examination*: tenderness to pressure at the carpal tunnel. Tinel's sign is positive (Fig. 2.33, paresthesia induced by tapping on the median nerve at the wrist). A late sign is thenar atrophy (Fig. 2.42). Positive bottle sign (Fig. 2.58; the thumb cannot be sufficiently abducted, and the bottle cannot be gripped). Positive Phalen test (in maximal flexion of the wrist, paresthesia sets in after 1–2 min).
- *Diagnostics*: neurological consultation (electromyography, electroneurography, new or old damage, denervation, repair).

Guyon's Canal Syndrome

Isolated or combined injury to the sensory and motor end branch of the ulnar nerve at the wrist.

- *Etiology*: fractures, cuts, scarring, infections, tumors (ganglia), and chronic compression injury during cycling and when doing certain work. The common cyclist's injury mostly only involves the motor branch of the ramus profundus.
- *History*: disturbed sensory function and/or atrophy of the dorsal interosseous muscles.
- *Examination*: sensory function disturbance mostly affects the pinkie and the ulnar side of the ring finger. The interosseous space between the thumb and the index finger appears gutted if motor function is impaired.
- *Diagnostics*: neurological consultation (electromyography, electroneurography, new or old damage, denervation, repair).

Cheiralgia Paraesthetica

Isolated compression injury of the sensory lateral branch of the radial nerve at the dorsal wrist or at the back of the hand.

- *Etiology*: wrist watch, handcuffs, and working with scissors or a painter's palette.
- *History*: pain and paresthesia at the back of the hand and the thumb.
- *Examination*: hypesthesia at the dorsal side of the radial 2 and 1/2 fingers. A focal local anesthesia test immediately relieves pain.

Further Literature

The examination of the upper extremities, 2009 by M.T.A. Boumans, A. van Ooy

Lower Extremity

A. Roth, *Orthopedic and Trauma Findings*, DOI 10.1007/978-3-662-53147-1_3

3.1 History

3.1.1 Localization and Kind of Complaint

Pain	Localization	Circumscribed/radiating
	Character	Numb/sharp/drilling/throbbing/burning/cramp-like
	Situation	During certain movements, under load/at rest, at night
Swelling	Location/extent	
Movement disorder	Location/kind/direction	Limitation of movement/locking/stiffness, walking distance
		Hypomobility (infants)
Walking distance	Reduced/normal	--km
Deformity	Location, kind	Altered posture, deformity
Sensory function disorder	Location, kind	Paresthesia/numbness/tingling/pins and needles
Motor function disorder		Gait uncertainty/muscular atrophy
		Weakness/ paralysis/spasticity
	Hip/knee/ankle/foot	Flexion/extension/abduction/adduction

3.1.2 Time Correlations

Beginning and course of disease	Congenital/acquired	(Age/point in time)
	Acute/chronic	
	Slowly/stably progressive	
	Occurs in flares with or without symptom-free intervals	

3.1.3 Concomitant Circumstances

Accident	Yes/no	
Location	Leisure/workplace	
Mechanism of injury	Triggering event	No triggering event/fall/bending/rising from a squatting position Height/weight/load/persons involved
	Motor vehicle accident	Type of vehicles involved/direction/speed, angle of impact, lateral, head-on or rear-end collision, head impact/headrest/safety belts
Preexisting conditions	Family medical history	
	Degenerative/bacteria/ rheumatic inflammatory	No/if yes: local/systemic

	Bacterial infection/viral infection	
	Traumatic/tumor	
	Malformations	
General symptoms	Fever, weight loss (time period of weight loss), fatigue, nocturnal sweating	Yes/no
Pregnancy (infants)	Caesarean, breech birth	Course/birth

3.1.4 Existing Treatment/Past Treatment

Medication	Medication/dose/duration of intake	Localized/systemic
	Relief	Yes/no
Physical therapy	Application	Forms/duration/frequency
	Relief	Yes/no
Orthopedic aids	Walking stick/crutches Basques/bandage Brace/cast	Yes/no
Operations	Time/site/type/success	

3.2 Hip and Upper leg

3.2.1 Systematic Examination

- **Local findings (children and adults)**

Gait	Inconspicuous/right-sided/left-sided limping	Painful limping, shortening limping, guarding limping, stiffened limping
Pelvis stance	Pelvic stance level/asymmetric	Right/left (--cm)
Axis	Physiological/pathological (right/left)	Femur varum Rotation (external/internal)
Swelling/redness/hyperthermia	None, if yes then:	Location/extent/circumference/consistency (soft/firm/movable)
Hematoma/abrasion/open wounds	None, if yes then:	Location/extent/circumference
Scars	None, if yes then:	Location/extent/consistency (soft/firm/movable)
Muscles	Buttocks/upper leg	Highly developed/wasted/shortened atrophy (significant?), muscle tone increase or decrease (right/left)
Trendelenburg's sign	Negative/positive (right/left)	

Mobility of the hips	Extension/flexion abduction/adduction external/internal rotation	--/--/--Degrees (passive, right/left)
	Drehmann's sign	Negative/positive (right/left)
Hip pain	Motion pain (active/passive, direction, continuous/at maximum ROM), groin pain, tenderness at the trochanter, piriformis flexion pain, traction pain/compression pain	None; if yes: positive (right/left)
	Impingement signs	Negative/positive (right/left)
Leg length	Absolute/relative	--cm (right/left)
Amputation stump length	Ischium end of the stump	--cm (right/left)

- **Local findings (infants)**

Hypomobility	None; if yes: (right/left)	
Symmetry of skin folds	None; if yes: (right/left)	Upper leg/buttocks
Leg shortening	None; if yes: (right/left)	
Inhibited abduction	None; if yes: (right/left)	
Ortolani	Historic test	Should not be performed anymore as it can lead to dislocation

- **Neurology**

Deep tendon reflexes	Quadriceps tendon reflex (L4) Posterior tibial reflex (L5) Achilles tendon (S1)	Right/left Vigorous/decreased/absent/supernormal (hyperreflexic)/cloni (right/left)
	Babinski Gordon Oppenheimer	Negative/positive (right/left)
Sensory function examination	Dermatome (segment assignable/not exactly assignable)	Hypesthesia/paresthesia/dysesthesia (right/left)
Motor function	Knee flexion/hip adduction (L3) Knee extension/hip abduction (L4) Standing on the heels (foot and big toe dorsiflexors; L5, sciatic nerve, peroneal nerve). Standing on the toes (foot plantar flexors; S1)	Right/left intact/impaired function (M0–M1–M2–M3–M4–M5)

- **Perfusion**

Arteries	Femoral artery Popliteal artery Dorsalis pedis artery Posterior tibial artery	Fully/barely/not palpable (right/left)
Veins	Varicosis cruris Venous stasis Hyperpigmentation	None/present (right/left)
Capillary pulse	Toe tips	Visible/invisible

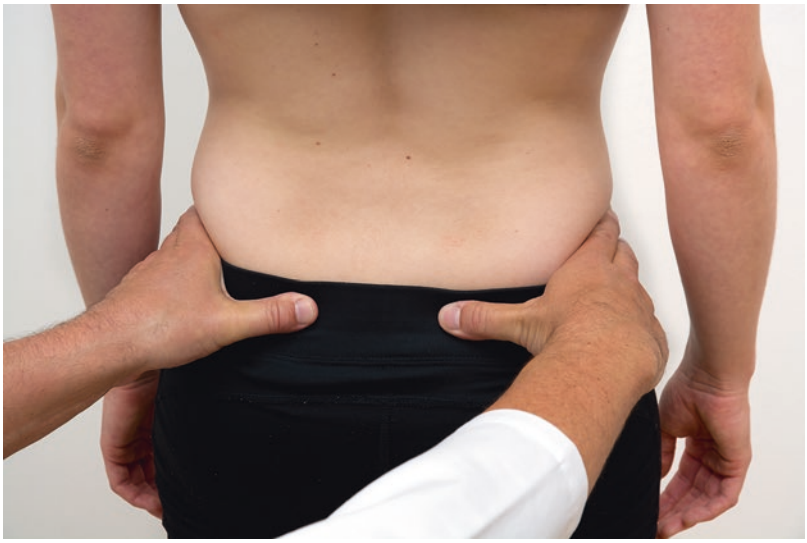


Fig. 3.1 Examining the pelvis. If the spinal crests are not level, a board, with a thickness of 0.5–1 cm, is placed underneath the shortened leg until equal length is reached. This way, the shortening compensation or the difference in leg length can be determined

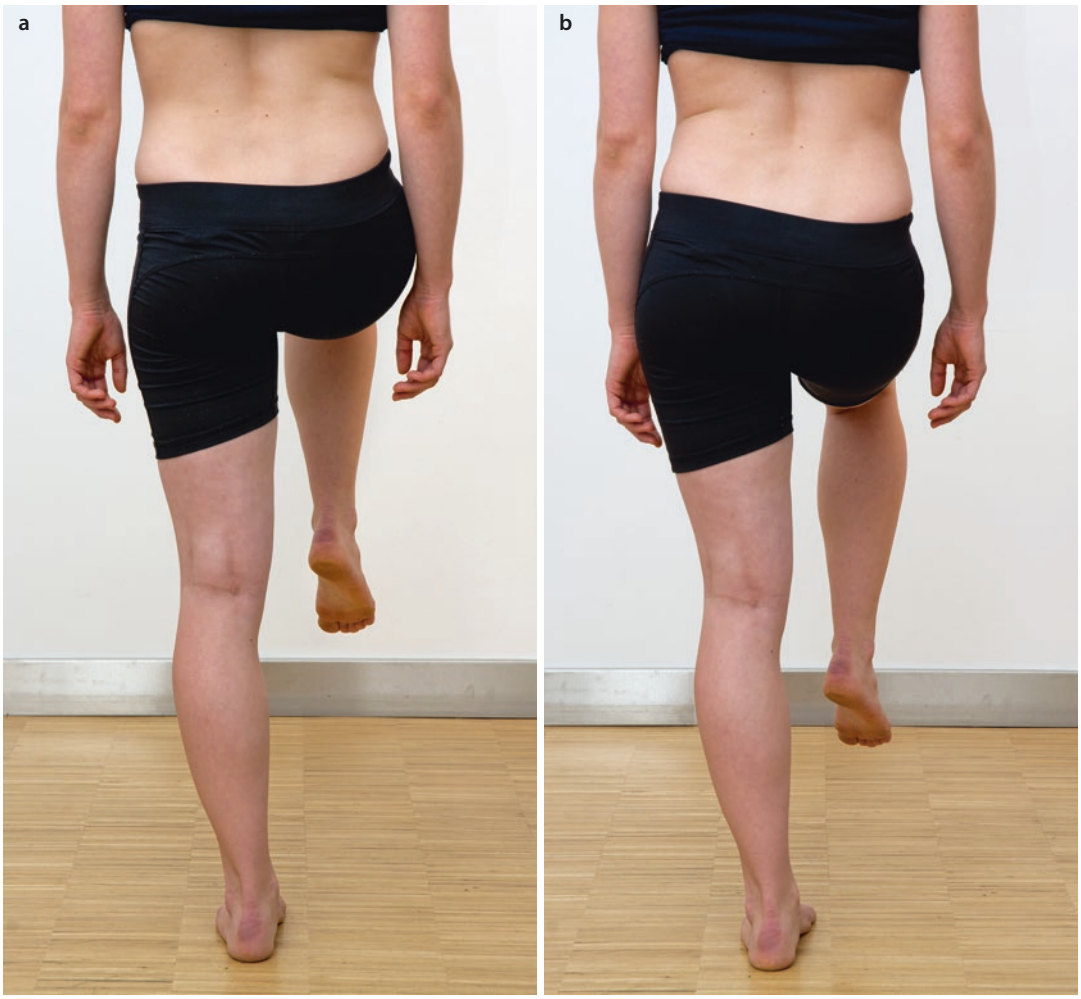


Fig. 3.2 (**a**, **b**) Testing the Trendelenburg's sign. When the patient stands on the healthy leg, the pelvis can be kept horizontally level: the test is negative (**a**). If the pelvis drops down on one side, the test is positive for the leg the patient is standing on (**b**). This suggests muscular insufficiency of the pelvicotrochanteric muscles of the affected leg (simulated in this diagram)

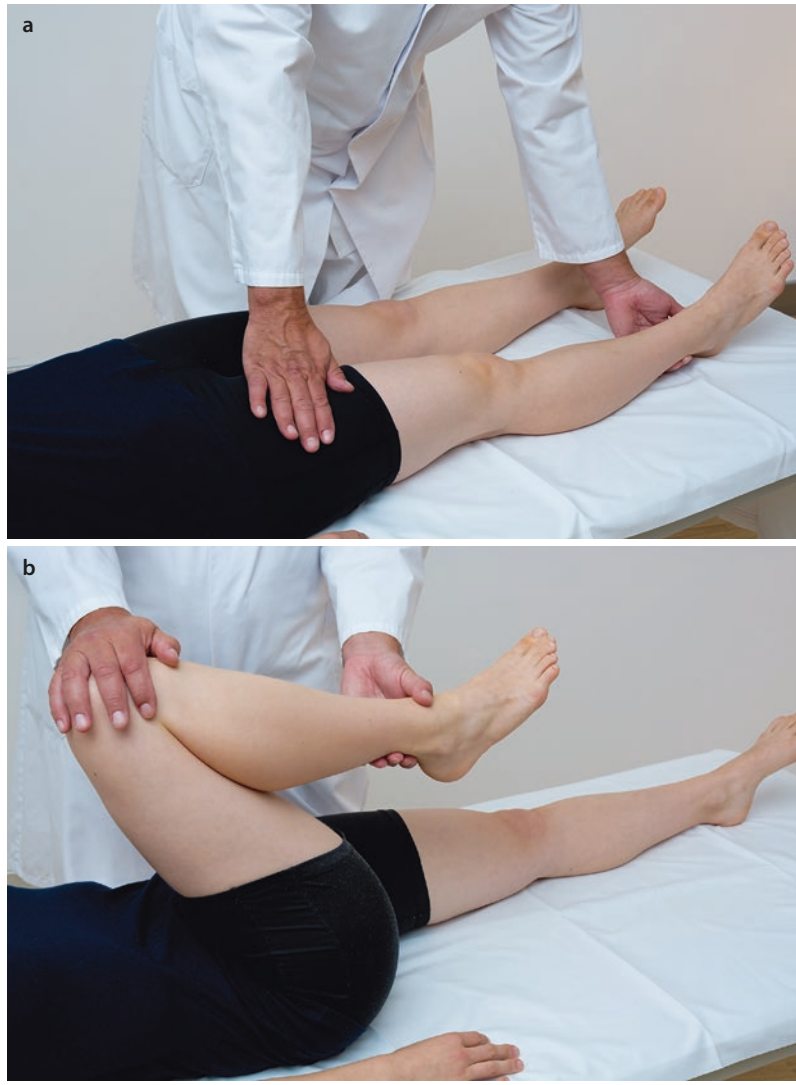


Fig. 3.3 (**a**, **b**) Testing extension/flexion in the hip joint. To test mobility in the hip joint, the patient must lie on his/her back. Extension is normally not tested. The examiner grabs the lower leg and stabilizes the leg at the knee joint with the opposite hand. The range of motion values for extension and flexion, external rotation, internal rotation, abduction, and adduction is recorded. Normal values for extension/flexion: 0/0/130–140°

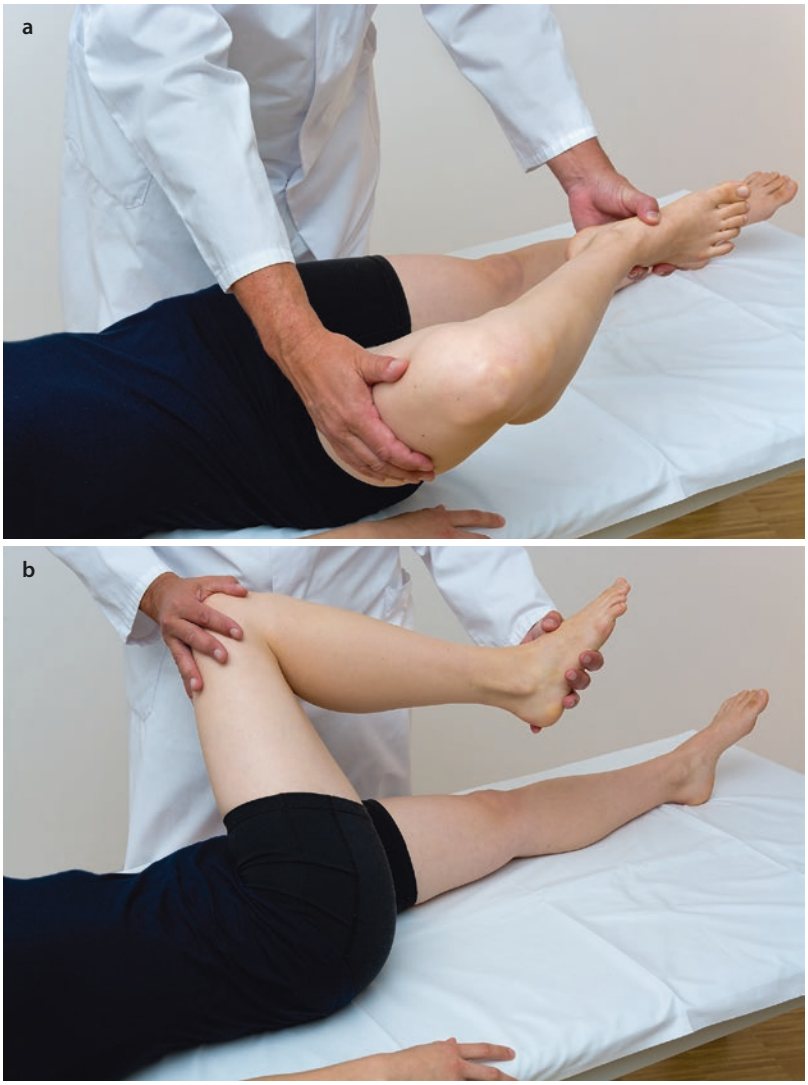


Fig. 3.4 (**a, b**) Testing for abduction/adduction in the hip joint. It is important to fixate the pelvis when performing the test to neutralize compensating movements from the opposite hip. Normal values for abduction/adduction: 30-45/0/20–30°

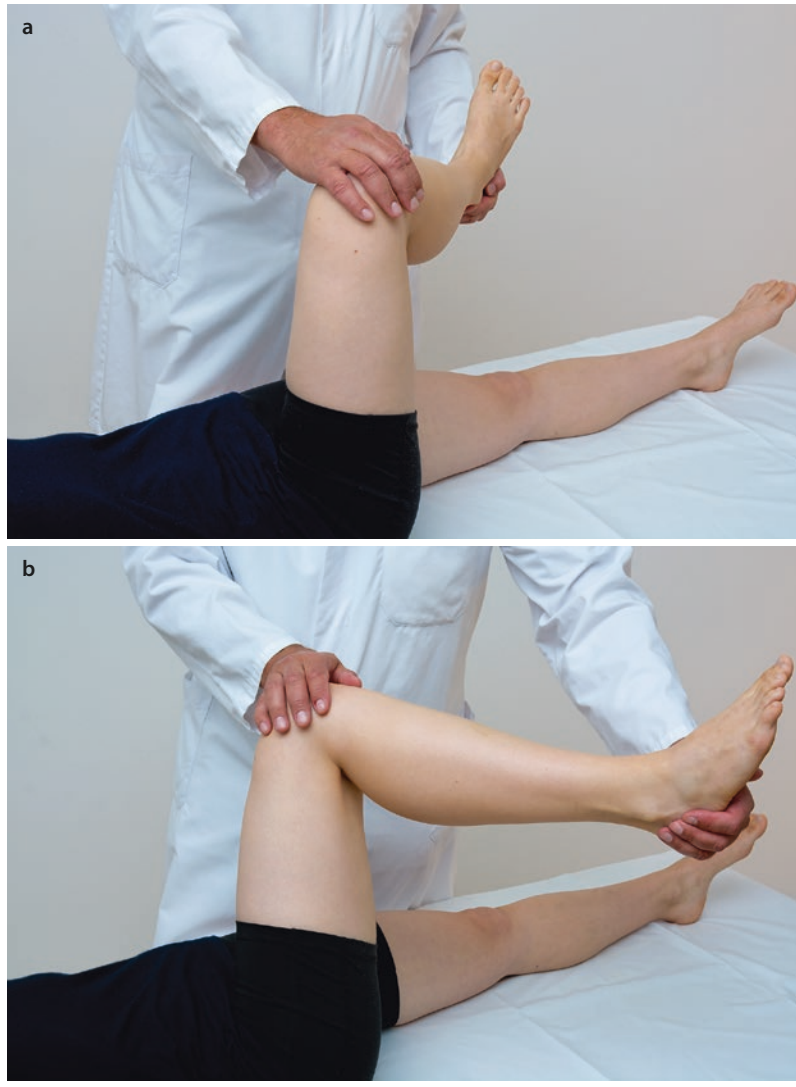


Fig. 3.5 (**a**, **b**) Testing external/internal rotation in the hip joint. The examiner bends the hip and the knee into a 90° angle. External rotation is tested by moving the foot inward and external rotation by moving the foot outward. Normal values for external/internal rotation: 40–50/0/30–45°.

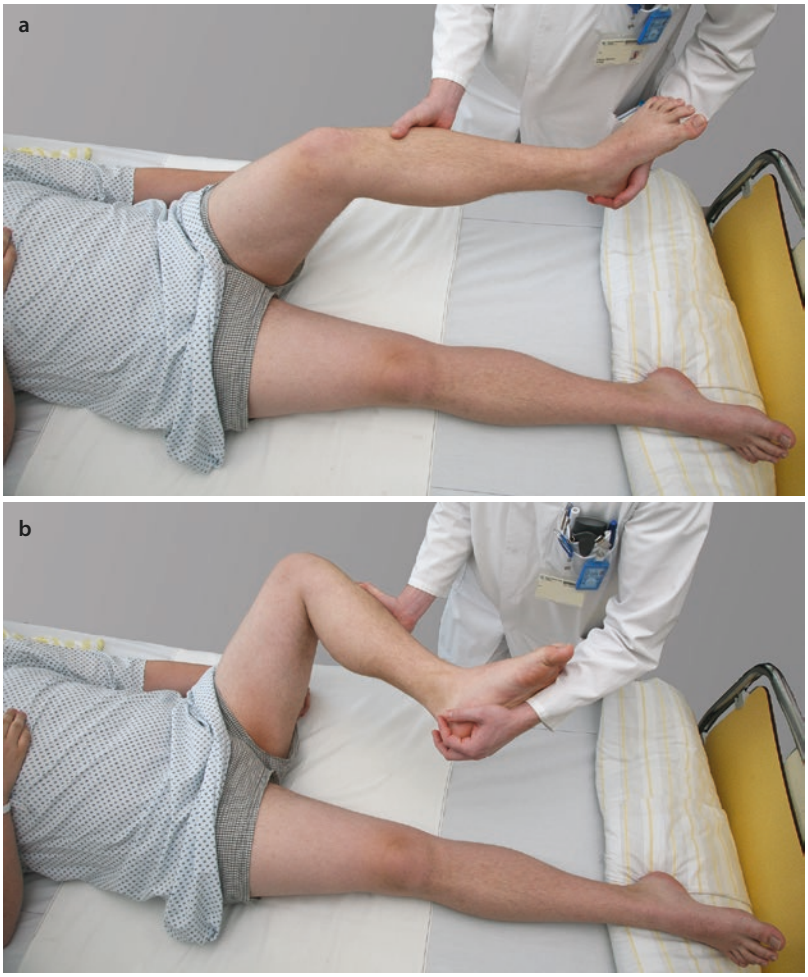


Fig. 3.6 (**a**, **b**) Drehmann's sign: if flexion in the hip joint is limited, the leg spontaneously externally rotates. The Drehmann's sign is positive if, during flexion of the hip joint, a spontaneous external rotation and abduction of the leg sets in. The sign is typically positive in slipped capital femoral epiphysis (Image courtesy of Dr. E. Schumann, University clinic Leipzig)

Fig. 3.7 Thomas test: serves to rule out flexion contracture in the hip joint. The patient is asked to hold onto the knee joint of the unaffected leg and to pull it toward the chest. The lumbar spine lordosis is flattened out and the flexion contracture in the hip joint becomes visible. During traction with forced flexion in the hip, the opposite, extended leg will lift off the table if contracture is present

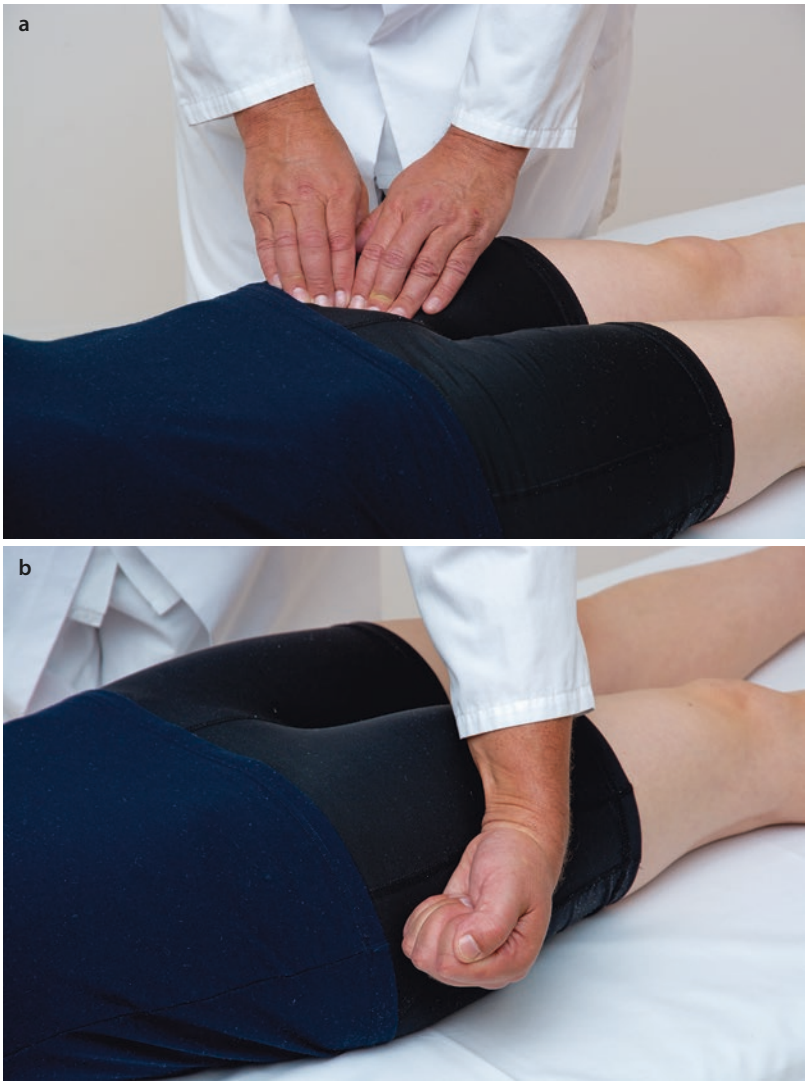


Fig. 3.8 (**a**, **b**) Points of tenderness: to determine pathologies of the hip joint, especially coxarthrosis, groin tenderness, and tenderness to tapping at the trochanter need to be tested. Groin tenderness (**a**) suggests inflammation in the acetabulum, and trochanter tenderness to tapping (**b**) suggests inflammation of the trochanteric bursa. Both can be a consequence of wear in the hip joint. Be careful: many hip disorders initially manifest with knee pain!

Fig. 3.9 Piriformis flexibility test: this test serves to show irritation in the piriformis muscle, especially as a differential diagnosis in unclear hip pain. The patient lies on his stomach. The examiner flexes the knee into a 90° angle. The dorsal trochanter is palpated with two fingers, and the lower limb is simultaneously internally rotated (moving the foot outward). The test is positive if the patient reports pain in the buttocks at the height of the major trochanter (insertion site of the piriformis muscle)

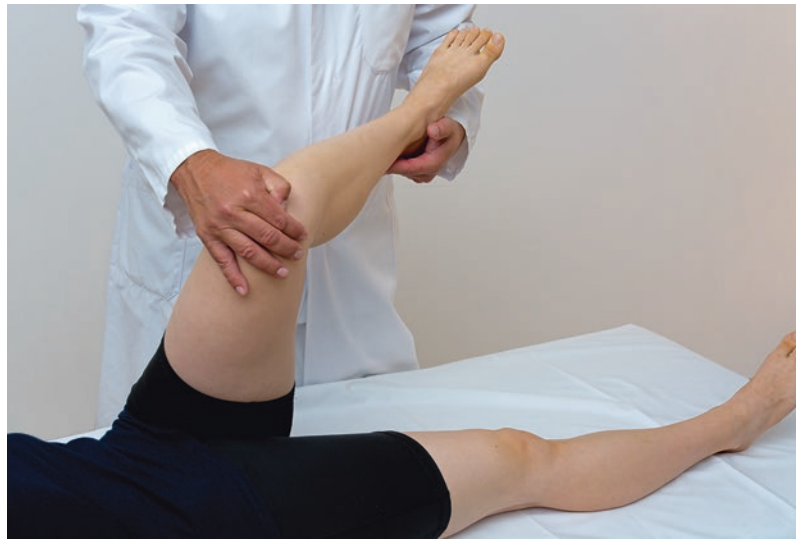


Fig. 3.10 Impingement test: serves to test injury to the labrum of the hip joint or the acetabulum. The hip is flexed to 90° and adduction is performed in the direction of the opposite shoulder. The test is positive if the patient reports groin pain

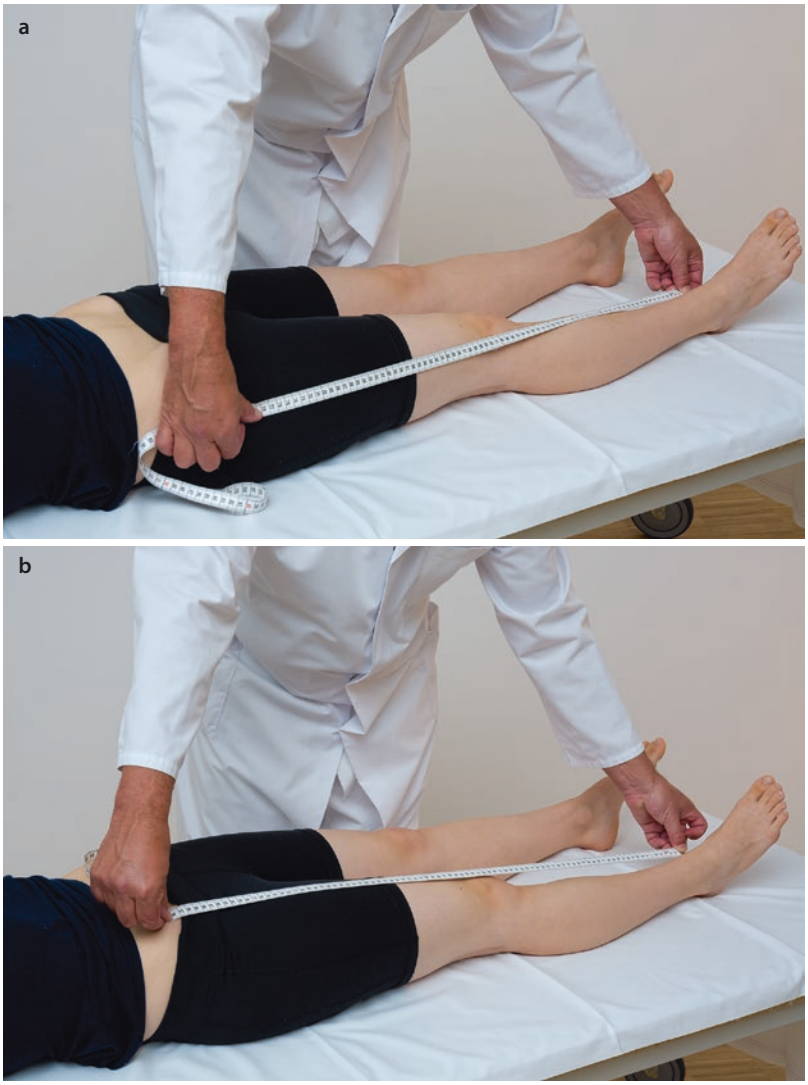


Fig. 3.11 (**a**, **b**) Measuring the absolute leg length (major trochanter/medial malleolus) (**a**) and the relative leg length (anterior superior iliac spine/medial malleolus) (**b**). Shortening of the relative leg length is usually caused by a disorder between the femoral neck and the pelvis

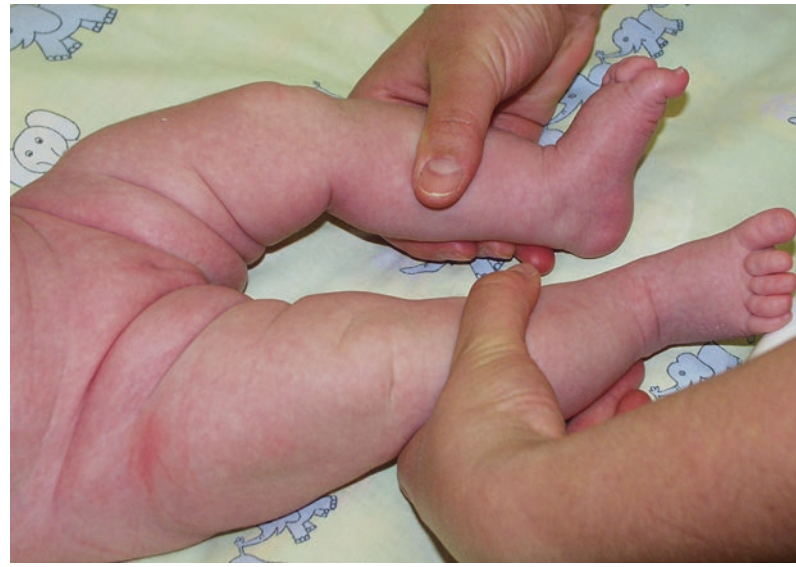


Fig. 3.12 Asymmetry in the skin folds. Typical for hip dysplasia

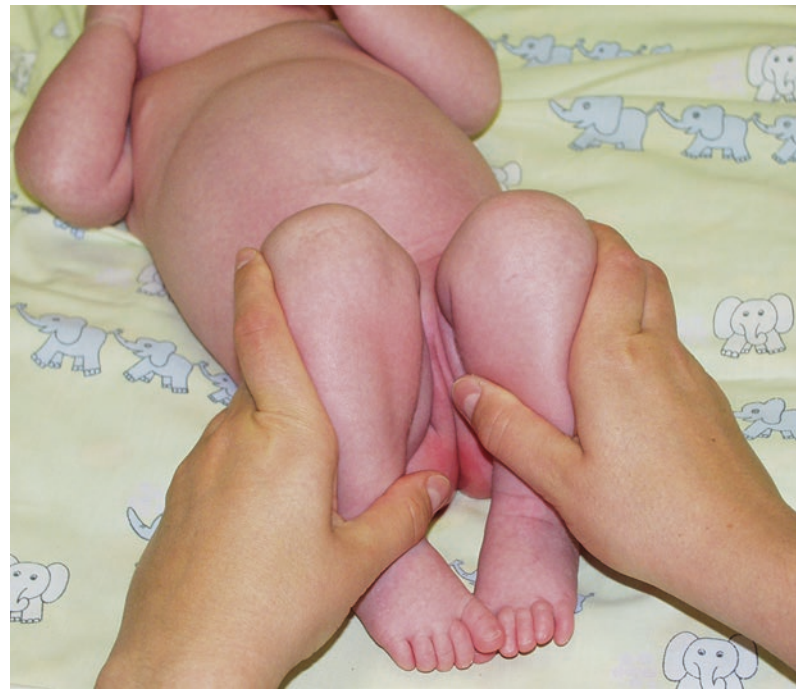


Fig. 3.13 Testing leg length difference in an infant. This is typical for hip dysplasia

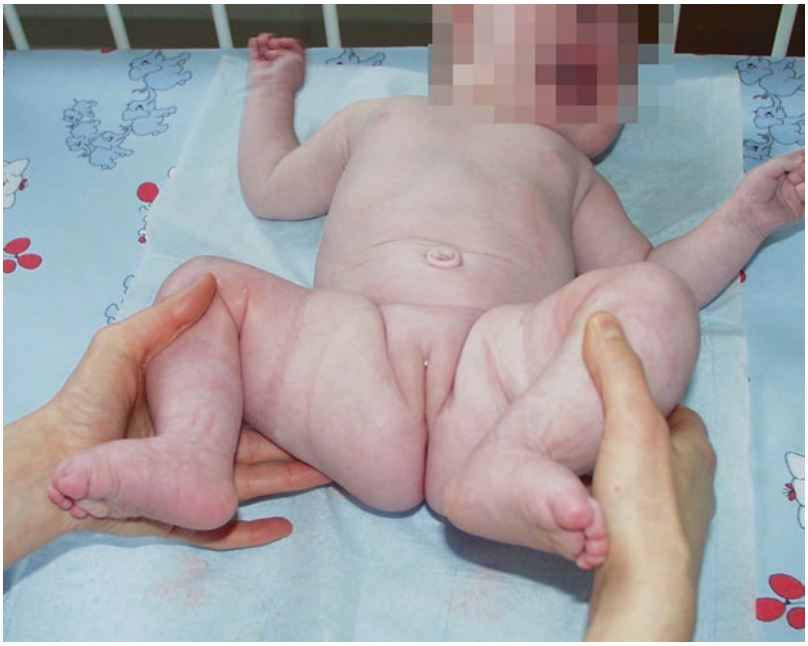


Fig. 3.14 Inhibited abduction in the left hip joint of the infant. This is typical for hip dysplasia

3.2.2 Leading Symptoms of the Hip and the Upper Leg

The leading symptoms of the hip and the upper leg are summarized in Table 3.1.

Table 3.1 Leading symptoms of the hip

History	Pain	Local findings, functional tests	Sensory function disorder	Motor function disorder	Points to
Age 15–16, prepuberty, often overweight, pasty children (adiposogenital type), fatigue, increasing limping	Initially often knee pain, in some cases sudden pain in the hip and leg with immobility	Painful limping, increasing external rotation flexion of the leg, leg shortening, groin tenderness, Drehmann's sign positive	None	None	*Slipped capital femoral epiphysis*
Age 3–9 easily tired, increasing limping	Initially often presents with knee pain, in course hip pain	Painful limping, groin tenderness, limitation of abduction and internal rotation, leg shortening	None	None	*Perthes disease*
Age 30–60, increasing limping	Initially often therapy-resistant knee pain, hip pain	Painful limping, groin tenderness, limitation of mobility (flexion often still possible) in course leg shortening, atrophy of the gluteal and upper leg muscles	None	None	*Femoral head necrosis of the adult,* differential diagnosis: pseudoradicular syndrome of the lumbar spine
Age 50–60, increasing limitation of walking distance	Initially often knee pain, in course also hip pain (starting with pain upon strain, then also at rest)	Painful limping, in course shortening limping, groin tenderness, mobility limitation (at first adduction and internal rotation), leg shortening, atrophy of the buttocks and upper leg muscles	None	None	*Coxarthrosis*
Total hip arthroplasty eventually exacerbating leg shortening (not obligatory)	Knee or hip pain (not obligatory)	Rotation pain, sometimes also traction pain and compression pain, eventually increased shortening compensation	None	None	*Implant loosening,* differential diagnosis Pseudoradicular syndrome of the lumbar spine
Child, stumbling over its own feet, walking with increasingly inwardly rotated feet	In some cases after completed growth, strain-dependent, groin pain	Sitting in the inverted cross-legged position (sitting with the inner thighs toward the floor) is possible. Internal rotation when lying on the abdomen is possible up to 90°. External rotation is limited	None	None	*Solitary coxa antetorta*

Infant, breech birth, preterm birth, sectio, hypomobility, delayed walking	None	Asymmetry of the folds at the upper leg and the buttocks, inhibited abduction, and leg shortening, in course positive Trendelenburg's sign	None	None	*Hip dysplasia*
Sudden snapping over the hips when walking	Often pain over the trochanter when snapping	Palpable snapping over the major trochanter when walking (with the flat palm of the hand)	None	None	*Coxa saltans*
Child, mostly younger than 10 years, preceding trauma or flu, limping, no fever	Sudden hip and knee pain (at rest and during movement)	Painful limping, external rotation position of the leg, mobility—especially internal rotation and abduction—are decreased	None	None	*Coxitis fugax*
Bacterial infection, punction, or surgery at the hip joint, patient cannot walk, fever, reduced general condition	At first diffuse and then severe groin and knee pain	Patient cannot walk, leg is fixed in adduction, flexion and external rotation, severe groin tenderness and tenderness to tapping at the trochanter, testing range of motion is not possible due to pain	None	None	*Nonspecific bacterial coxitis*
Mostly older patients, following minor injury (a fall in a domestic context)	Groin pain	Patient cannot walk, the leg is shortened, externally rotated and adducted	None	None	*Femoral neck fracture*
Younger patient, adequate trauma (traffic accident)	Severe groin pain and leg pain	Patient cannot walk, the leg is shortened, flexed in the hip, adducted, and internally rotated	Hypesthesia at the sole of the foot	Foot dorsiflexor paresis	*Posterior hip dislocation* (with injury to the sciatic nerve)

3.2.3 Disorders of the Hip

- **Clinical pictures**

■ *Snapping Hip Syndrome (Coxa Saltans)*

Sudden snapping of the iliotibial tract over the major trochanter during active movement of the hip joint.

- *Etiology*: Constitutional loosening of the iliotibial tract. Congenital or acquired disorder involving the major trochanter or affecting leg length is rare.
- *History*: Mostly young girls. Unintentionally or intentionally induced snapping over the major trochanter. Often painful.
- *Examination*: Localized tenderness to pressure over the major trochanter. Palpable snapping over the major trochanter during walking or when standing up from a hunched position. Not inducible in a prone position. In some cases, a difference in leg length may be found (◘ Figs. 3.1 and 3.11).
- *Diagnostics*: Ultrasound (dynamic examination), eventually X-ray of the hip in two planes.

■ *Piriformis Syndrome*

Painful shortening of the piriformis muscle.

- *Etiology*: Overuse injury.
- *History*: Localized, sciatic pain in the buttocks. The pain occurs at rest and is exacerbated by movement.
- *Examination*: Tenderness to pressure over the buttocks, medial to the top of the major trochanter. The piriformis flexion test is positive (◘ Fig. 3.9, pain provocation by internal rotation of the hip when the patient lies on his/her stomach). Painful abduction and external rotation against resistance.
- *Diagnostics*: If pain persists, X-ray of the hips in two planes, eventually including the lumbar spine in two planes (to rule out degenerative changes).
- *DD*: Sciatica and coxarthrosis.

■ *Slipped Capital Femoral Epiphysis*

Dislocation of the femoral head epiphysis from the femoral neck. This dislocation is associated with slippage of the femoral head mostly in a posterior-caudal direction. Slippage is mostly slow (chronic) but can also, in rare cases, be acute. The acute form can also develop into the chronic form.

- *Etiology*: Unknown for both the acute and chronic forms. Endocrine factors are being discussed. Atraumatic structural loosening.
- *History*: Prepubertal children are commonly affected (boys 12–16 years, girls 10–14 years). Conspicuous bodily constitution, obesity, children with a pasty appearance and hypogonadism (adiposogenital type).
  Chronic form: Initially little, uncharacteristic pain in the hip, back, and leg, often also knee pain. Patients soon feel fatigued when walking or standing, and in the course of disease, a limp may develop.
  Acute form: Almost no complaints or complaints resembling the chronic form. Then a sudden inability of the hip to bear load. Pain and immobility.
- *Examination*: Painful limp and leg shortening in advanced disease. External rotation of the leg. Groin pain and clear and painful reduction in leg abduction (◘ Fig. 3.4) and internal rotation (◘ Fig. 3.5). Positive Drehmann's sign (◘ Fig. 3.6): in passive hip flexion from the neutral position, external rotation must increase.

In the acute form, the risk of secondary femoral head necrosis exists. Acting quickly is essential!

- *Diagnostics*: X-ray of the pelvis and the hips axially (Lauenstein, to visualize the slippage and to determine the slippage angle).

■ *Legg–Calvé–Perthes Disease*

Partial or complete necrosis of the femoral head commonly affecting the growth plate and the metaphysis in childhood. One distinguishes four typical stages: initial stage, fragmentation stage, reossification stage, and healed stage. This process takes 2–4 years, during which the epiphysis should not be exposed to too much load as the risk of deformation exists.

- *Etiology*: Unknown. Ischemia, congenital vascular anomaly, and hormonal dysregulation.
- *History*: More common in boys than girls. Commonly presents from the ages 3–9. Bilateral in about 20 % of cases, yet mostly begins with one hip. Early signs are especially knee pain. Mild pain in the hip. Patients report pain-free intervals in between, followed by sudden fatigue and limping.

- *Examination*: Initially, mostly a limitation in abduction. Then a limitation of internal rotation (◘ Figure 3.5, examined with the patient lying down) and pain during movement close to the maximum range of motion. In course, flexion contracture, atrophy of the buttocks and upper leg muscles, and compensation for the muscle shortening (◘ Figs. 3.1 and 3.11, relative leg length decreased). Trendelenburg's sign positive (◘ Fig. 3.2).
- *Diagnostics*: X-ray of the hips in two planes (the range of the bony changes according to Catteral). MRI (to show the necrosis in its early stages, differential diagnosis).
- *DD*: Transient synovitis. Septic coxitis. Epiphyseal dysplasia.

■ Femoral Head Necrosis in Adults

Ischemic, atraumatic, and noninfectious femoral head necrosis of adults.

- *Etiology*: Unknown. An arterial perfusion deficit is assumed. Also occurs following steroid treatment, alcohol abuse, kidney transplant, and chemotherapy. Furthermore, seen following radiation (often only presenting years post-exposure!), in metabolic disorders (hyperuricemia, dyslipidemia, Gaucher's disease) or following pancreatitis. Hematological disorders (e.g., sickle cell anemia) and vascular disorders (e.g., peripheral artery disease, thrombosis, panarteritis nodosa, and connective tissue diseases).
- *History*: Mostly men aged between 30 and 60. In about 50 % bilateral, commonly one side follows the other within 2 years. After this, the risk of the opposite side being affected decreases. Often presents as pain-resistant knee pain. Patients report increasing groin pain radiating into the thighs with an impaired range of motion. Leg shortening, pain at rest and during movement, and limitation of the walking distance.
- *Examination*: Initially presents with nonspecific symptoms. Groin tenderness is common, eventually also painful limping. Atrophy of the buttocks and the upper leg muscles, including shortening of the leg in the advanced stage (this also involves limping). Leg shortening also leads to mobility impairment; flexion is commonly preserved for a longer time period.

Unclear knee complaints must always draw the examiner's attention to the hip joint as well.

- *Diagnostics*: X-ray of the hips in two planes. MRI is the gold standard to obtain a closer examination of the localization and extent of the necrosis. CT scans are recommended to rule out subchondral fracture. Scintigraphy (increased accumulation) only if contraindications exist for other diagnostic methods.
- *DD*: Sciatica. Coxarthrosis. Rapidly Destructive Osteoarthritis. Coxitis. Tumors.

■ Protrusio Acetabuli

Pathological deepening and protrusion of the acetabulum into the pelvis. The femoral head is located deeper and is surrounded by the acetabulum. Is mostly associated with secondary coxarthrosis.

- *Etiology*:
  Primary form: Following disturbed ossification of the acetabulum.
  Secondary form: Seen in rheumatoid arthritis, bacterial coxitis, and osteomalacia, following traumatic hip dislocation, hemiendoprosthesis, etc.
- *History*:
  Primary protrusio acetabuli: Always bilateral. Mostly in younger adults and in mid-adulthood. Pain only sets in once the disorder progresses into secondary coxarthrosis.
  Secondary protrusio acetabuli: Determined largely by the underlying disorder. Pain, movement impairment, and limitation of the walking distance.
- *Examination*:
  Primary protrusio acetabuli: Hyperlordosis of the lumbar spine. Limitation of rotation and extension in the hip joint. In course, signs of secondary coxarthrosis.
  Secondary protrusio acetabuli: Painful limping. Shortening compensation (the height of both spinal crests are palpated, and the two sides are equalized by placing a board under the shortened side; the height of the board is the alteration of length required to reach a level standing pelvis). Atrophy of the buttocks and the upper leg muscles. Groin tenderness, tenderness to tapping at the trochanter, and painful limitation of movement.

- *Diagnostics*: X-ray of the pelvis. Functional imaging (to visualize damage and its influence on mobility).
- *DD*: All etiologically relevant differential diagnoses.

■ Femoroacetabular Impingement

Mechanical conflict between the anterior acetabular margin at the pelvis or its circular cartilage ridge and the anterior femoral neck. Impingement leads to pain in the hip. One distinguishes between pincer femoroacetabular impingement (*retrotorsion of the acetabulum or the coverage of the femoral head appears too great, e. g., in protrusio acetabuli or coxa profunda*) *and cam femoroacetabular impingement* (*bony protrusions at the femoral neck close to the hip joint*). *A combination of both forms is mostly present*.

- *Etiology*: Cam impingement probably occurs due to a slippage of the femoral head during the growth phase, causing the normal junction between the head and the femoral neck to change (also called an offset disorder). In pincer impingement, the femoral head is surrounded by the acetabulum like a pincer. This disorder already presents in toddlers or in childhood. In both cases, the femoral neck comes into contact with the acetabulum ridge and damages the acetabular labrum as well as the cartilage.
- *History*: Pain especially during hip flexion, partly radiating into the lower limb. During flexion of the hip or internal rotation of the leg, sharp groin pain can be felt. Often presents during periods of long driving or during strain. In the late stage, the hip joint suffers wear and subsequent movement impairment sets in.
- *Examination*: Pain during adduction and simultaneous internal rotation (positive impingement test; ◘ Fig. 3.10). Internal rotation pain disappears when the patient performs a slight abduction (in contrast to coxarthrosis).
- *Diagnostics*:

X-ray anterior–posterior in the Lauenstein position: The normal slimming in the middle is lacking and there is bone accumulation at the junction between the femoral head and the femoral neck (cam impingement); crossover sign of the acetabulum as a sign of retroversion in the anterior–posterior imaging and cranial covering of the acetabulum (pincer impingement).

- *DD*: Initial coxarthrosis and dysplasia

■ Total Hip Endoprosthesis Loosening

Loosening of a total hip endoprosthesis. Can present as an early or late loosening of the implant. Currently cemented implants remain stable for 12–20 years. Loosening can also present earlier and in rare cases later. In cementless implants, longer stability should be expected.

- *Etiology*: Aseptic loosening under the influence of polyethylene particles set free from the cup implant due to wear. The etiology is not always clear. Septic loosening occurs during early infections following implantation of a prosthesis and as a late infection following hematogenous spreading from a different focus of infection (tonsillitis, pyelonephritis, infected pseudoexostosis in a context of severe bunion—hallux abducto valgus).
- *History*: Often nonspecific. Pain in the joint on rising. Hip, knee, or upper limb pain. Shortening of the operated leg. In some cases, palpable movement of the implant. Reduction of the walking distance.
- *Examination*: Limping gait, eventually positive Trendelenburg's sign (◘ Fig. 3.2). Increase in the shortening compensation in comparison to earlier examinations. Pain induced by traction or compression is not always present, and it represents an uncertain sign of loosening. Pain during rotation at the maximum range of motion. In septic loosening, fistula can occur around the scar.

The clinical findings are often nonspecific. The extent of the bone defects occurring in the context of loosening does not always correlate with reported pain and physical findings. A loosened prosthesis without large bone defects can elicit more pain than a loosening involving extensive bone loss.

- *Diagnostics*: X-ray of the hips in two planes (to visualize a loosening—radiolucent lines, altered position). Scintigraphy (increased accumulation). Swab/puncture of the infection sight.
- *DD*: All etiologically relevant differential diagnoses. Pseudoradicular syndrome of the lumbar spine.

- **Congenital deformity and metabolic defects**

Hip Dysplasia and Hip Dislocation

Hip dysplasia is a dysplasia of the acetabulum without a dislocation of the femoral head. It is associated with coxa valga and coxa antetorta (pathologically increased antetorsion of the femur neck). In hip dislocation (luxatio coxae congenita), a subluxation or dislocation of the femoral head sets in from the dysplastic acetabulum. It is also known as congenital hip dislocation and secondarily leads to coxarthrosis.

It is important to distinguish teratologic hip dislocation, in which the femoral head is primarily located next to the acetabulum (also known as prenatal dislocation).

- *Etiology*: Multifactorial genetic illness (regional increases in incidence are found in Germany in the federal states of eastern Thuringia, Franconia, and Saxony as well as in the Czech Republic, Slovakia, Hungary, Finland, Jamaica, and the state of Pennsylvania). More common in babies born by breech birth.
- *History*: In about 2–4 % of all births in Germany. Six times more common in girls compared to boys. Familial predisposition. Breech birth, preterm birth, or caesarean section. Other malformations (pes calcaneus, pigeon toe, clubfoot, muscular torticollis). Decreased mobility, guarding of the leg when crawling, and slowed walking. In remaining dysplasia, pain often only sets in during middle age.
- *Examination*: Asymmetry of the skin folds (Fig. 3.12). Inhibited abduction (Fig. 3.14) and leg shortening (Fig. 3.13) in side comparison (be cautious of bilateral disease!). Positive Ortholani sign (should not be tested due to risk of dislocation!). Trendelenburg's sign (Fig. 3.2), unilateral or bilateral Trendelenburg's limping. If dysplasia remains in middle age, internal rotation increases when the patient lies on his stomach.

For the course of this disorder, the early examination is essential. Clinical signs and findings are nonspecific and need to be supplemented by further diagnostic tests.

- *Diagnostics*: Ultrasound. X-ray of the pelvis (after the third month, following therapy). If there is insufficient cover for the femoral head in the X-ray, the remaining dysplasia should be suspected (center edge angle). MRI should be performed to rule out arthrosis signs (damage to the labrum, cysts).
- *DD*: Dislocation in infantile cerebral palsy and in myelomeningocele. Teratogenic hip dislocation.

Solitary Coxa Antetorta

Pathological enlargement of the antetorsion angle of the femur neck. Mostly bilateral. Also known as idiopathic coxa antetorta.

- *Etiology*: Congenital deformity or delayed involution of the increased antetorsion which is physiological in childhood. Also associated with other congenital deformities of the hip joint, especially congenital hip dislocation.
- *History*: Pain is absent. Affected children walk with their feet increasingly rotated inward and stumble over their own feet. In some cases, following the end of growth, strain-dependent pain can occur.
- *Examination*: When testing rotation with the patient lying on their stomach, internal rotation up to 90° is possible (Fig. 3.5), and external rotation is limited. Sitting in the inverted cross-legged position (sitting with the inner thighs toward the floor) is possible.
- *Diagnostics*: X-ray of the pelvis. Rippstein imaging (determining the exact angle).
- *DD*: Solitary coxa valga. Hip dysplasia. Hip dislocation.

Solitary Coxa Valga

Pathological increase the collodiaphyseal angle.

- *Etiology*: Congenital (*constitutional coxa valga*).

Acquired coxa valga: Spastic or flaccid paresis. Injury to the epiphyseal growth plate (inflammation, trauma, tumor). Femoral neck or subtrochanteric fractures healed in a malposition. Common after successful conservative dysplasia treatment.

- *History and Examination*: *Constitutional coxa valga* is mostly inconspicuous. *Acquired coxa valga* is determined by whether or not secondary coxarthrosis occurs.
- *Diagnostics*: X-ray of the pelvis. Rippstein imaging (exact determination of the angle).
- *DD*: Solitary coxa antetorta. Hip dysplasia. Hip dislocation.

Coxa Vara Congenita

Varus deformity with a shortening of and thickening of the femur neck. The physiological collodiaphyseal angle is decreased.

- *Etiology*:
  Primary form: Malformation that set in prior to birth.
  Secondary form: Hypoplasia in the growth plates of the epiphysis of the femoral neck leading to a varus deformity.
- *History*: Mostly unilateral. Limping sets in when the toddler begins to walk.
- *Examination*: Limping, Trendelenburg's limping, and positive Trendelenburg's sign (Fig. 3.2). Decreased abduction. In the course of disease, concentric movement impairment.
- *Diagnostics*: X-ray of the pelvis (to visualize changes to the joint).
- *DD*: Coxa vara symptomatica (following systematic disorders, local development disorders, trauma, inflammation, and tumors).

- **Degenerative disorders**

Coxarthrosis

Degenerative changes to the hip joint

- *Etiology*:
  Primary coxarthrosis (about 25%): Unknown etiology.
  Secondary coxarthrosis (75%): Congenital hip dislocation (30%), slipped capital femoral epiphysis (20%), and inflammatory disorders (10%). Less commonly Legg–Calvé–Perthes disease, trauma, chronic polyarthritis, and psoriatic arthritis, among others.
- *History*: Mostly begins between 50 and 60. Secondary coxarthrosis can present earlier depending on the structural damage. Often begins with knee pain. Pain at rest and under strain usually sets in later. In some cases, no pain is felt (e.g., depending on the activity of the coxarthrosis). Limitation of the walking distance.
- *Examination*: Painful limping, in the course of the disorder also a shortening limping and differing leg length. Groin pain, tenderness to tapping over the trochanter (Fig. 3.8) and tenderness to pressure over the sacroiliac joint (Fig. 1.34). Mennel's sign is positive (Fig. 1.35) and a positive Patrick's test (Fig. 1.36) is often positive. Adduction and internal rotation are commonly the first movements that are impaired, followed by other movements (Figs. 3.3, 3.4, and 3.5). Flexion contracture (Fig. 3.7, Thomas test), hyperlordosis of the lumbar spine. Also atrophy of the gluteal and the upper limb muscles.
- *Diagnostics*: X-ray of the hips in two planes (to visualize wear).
- *DD*: Femoral head necrosis. Inflammation (rheumatic, nonspecific). Tumor.

- **Inflammatory disorders**

Nonspecific Inflammation

Transient synovitis of the hip

Transitory inflammation of the hip joint in children.

- *Etiology*: Unknown. Eventually allergic, toxic, or infectious.
- *History*: Mostly children younger than 10. Often following flu or smaller trauma. Sudden hip and knee pain, pain at rest and during movement. Guarding, limping, absent fever, and no subjective impairment of the general condition. Usually clears within 1–2 weeks.
- *Examination*: Painful limping, groin pain, and the leg is externally rotated. Mobility (especially internal rotation, Fig. 3.5 as well as abduction during flexion, Fig. 3.4) is painfully limited.
- *Diagnostics*: X-ray of the hips in two planes (to rule out pathological changes to bone, differential diagnosis). Ultrasound (effusion). Blood tests (inflammation markers inconspicuous). Eventually puncture/swab.
- *DD*: Legg–Calvé–Perthes disease, nonspecific bacterial coxitis.

Nonspecific bacterial coxitis

Purulent infection of the hip joint. Prototype for infectious arthritis.

- *Etiology*: Almost always staphylococcal. Often the focus is at a different location involving hematogenous spreading. Also as phlegmon from the surrounding tissue. Coxitis can also be caused by direct infection (puncture, operation, open wounds).
- *History*: At first, diffuse groin pain and then upper leg and knee pain. Debilitated general condition and fever. Patients cannot walk anymore. Examination is only possible when

lying down. Severe pain in the hip during the slightest movement.
- *Examination*: The leg is adducted, flexed, and externally rotated. Pain upon palpation, severe groin tenderness to pressure, and tenderness to tapping at the trochanter. Testing range of motion is not possible due to the severity of the pain!
- *Diagnostics*: X-ray of the hips in two planes (to rule out pathological changes to bone, differential diagnosis). Ultrasound (effusion). Blood tests (erythrocyte sedimentation rate, leukocytes, CRP). Puncture/swab.
- *DD*: Specific coxitis. Postinfectious reactive coxitis. In children younger than 10, transient synovitis of the hip or an early stage of Legg–Calvé–Perthes disease.

- **Traumatic disorders**

Traumatic Hip Dislocation

This is a serious injury that is easily overlooked in the context of polytrauma. Anterior and posterior dislocations are surgical emergencies due to the risk of femoral head necrosis, requiring immediate relocation.

Posterior hip dislocation.

By far the most common type of traumatic hip dislocation. Often in combination with other injuries of the lower extremities. In 10 % of cases, associated with injury to the sciatic nerve.
- *Etiology*: Severe force translated via the femur shaft and the major trochanter, involving adduction and flexion of the hip.
- *History*: Severe pain!
- *Examination*: The leg is shortened, adducted, flexed, and internally rotated. Injury to the sciatic nerve can be tested via paresis of the dorsiflexors of the foot (Fig. 1.47) and hypesthesia at the sole of the foot (Fig. 1.46).
- *Diagnostics*: X-ray of the pelvis and hips with the upper legs in two planes (to rule out fracture, to visualize dislocation).
- *DD*: Femur neck fracture. Femur shaft fracture.

Anterior hip dislocation

Less common type of traumatic hip dislocation. Neurovascular injury is possible.
- *Etiology*: Severe force translated via the femoral shaft and the major trochanter involving abduction and flexion in the hip.
- *History*: Severe pain!
- *Examination*: The leg is shortened, abducted, and externally rotated. Neurological deficits are possible (weakened knee flexion, hypesthesia at the anterior thigh—Fig. 3.49).
- *Diagnostics*: X-ray of the pelvis, the hips, the upper legs, and the knee joint in two planes (to rule out fracture, to visualize the dislocation).
- *DD*: Femur fracture. Femur shaft fracture.

Central hip dislocation.

Severe injury also affecting the organs of the pelvis.
- *Etiology*: *Severe force that is translated via the major trochanter toward the femoral head.*
- *History*: Severe pain!
- *Examination*: The leg is mostly shortened and fixed in the neutral position.
- *Diagnostics*: X-ray of the pelvis, the hip with the upper legs, and the knee in two planes (to rule out fracture or dislocation).
- *DD*: Femur neck fracture. Femur shaft fracture.

Proximal Femur Fractures/Femur Shaft Fracture

Femur shaft fracture/femur neck fracture/intertrochanteric fracture.

Medial (most common), intermediate, or lateral femur neck fracture.

Depending on the angle of the fracture (between the horizontal plane and the fracture line), three grades are distinguished according to Pauwels: Pauwels I, <30°, abduction fracture; Pauwels II, 30–70°, adduction fracture; and Pauwels III, >70°, avulsion fracture. Depending on the dislocation of fragments, a further classification according to Garden 1–4 is used.
- *Etiology*: Fall—often at home (minor trauma). Weak bones (osteoporosis, osteomalacia).
- *History*: After the fall, the patient reports groin pain.
- *Examination*: The leg is shortened, mostly adducted, and externally rotated. Groin tenderness. Due to pain, testing mobility is not possible.
- *Diagnostics*: X-ray of the hips in two planes (to visualize the fracture).
- *DD*: Femur shaft fracture. Subtrochanteric femur fracture.

Subtrochanteric femur fracture

Femur fracture below the trochanter. Relatively rare.

- *Etiology*: Almost always a pathological fracture.
- *History* and *Examination:* Are similar to the other proximal femur fractures. If a pathological fracture is suspected, the examiner should look for a focus.
- *Diagnostics*: X-ray of the hip in two planes (to visualize the fracture).
- *DD*: Femoral neck fracture. Intertrochanteric fracture. Femur shaft fracture.

Femur neck fracture in children

Divided into subcapital, transcervical, cervicobasal, and intertrochanteric fracture. Due to the common perfusion disturbance of the femur head, this fracture mostly leads to femur head necrosis and secondary coxarthrosis within 2 years.

- *Etiology*: Mostly adequate trauma is involved (e.g., motorcycle accident) or an underlying disease (osteogenesis imperfecta, juvenile bone cyst, tumors).
- *History*: Severe pain in the hip and the leg.
- *Examination*: The leg is shortened, adducted, and externally rotated. Groin tenderness. Testing range of motion is not possible due to pain.
- *Diagnostics*: X-ray of the hip in two planes (to visualize the fracture).
- *DD*: Femur shaft fracture.

Femur shaft fracture in adults

As spiral and horizontal fracture of the femur shaft. Often associated with severe blood loss, especially in young adults, and can lead to shock.

- *Etiology*: Severe force in adults (in children also lesser force). Spiral fracture via torsion. Horizontal fracture via snapping force. Horizontal fractures are also morphologically typical for pathological fractures.
- *History*: Severe pain. Malpositioning of the leg.
- *Examination*: In some cases, swelling of the upper leg. The leg may be shortened. External rotation, abduction, and flexion of the leg proximal to the fracture. Medial displacement of the leg distal to the fracture. Pain prevents the examiner from testing range of motion in the hip and the knee.
- *Diagnostics*: X-ray of the hips with the upper leg and the knee in two planes (to visualize the fracture).
- *DD*: Femur neck fracture. Intertrochanteric fracture. Pathological fracture.

- **Tumor disorders**

■ *Primary Tumors*

Chondrosarcoma

Primary and secondary chondrosarcoma. After osteosarcoma, it is the second most common malignant bone tumor. Mostly affects the long bones and the bones of the skeletal trunk, the pelvis, and the shoulder. Grows slowly with lymphatic metastasis. Classified according to malignancy in grades I–IV. The closer the tumor is to the skeletal trunk, the higher its malignancy.

- *Etiology*: Main representative of malignant cartilage tumors.
- *History*: Mostly presents in adults. Symptoms include nonspecific pain, e.g., at the knee joint, often lasting years. In some cases only noticed due to swelling.
- *Examination*: Palpable swelling at the upper leg. Localized tenderness.
- *Diagnostics*: X-ray of the upper leg with the hips in two planes (to visualize the tumor). Scintigraphy (increased accumulation). CT/MRI (localization and extent of the tumor). Biopsy.
- *DD*: Enchondroma.

- **Neurological disorders**

■ *Meralgia Paresthetica*

Injury to the sensory lateral femoral cutaneous nerve (L2–L3) at its passage from the external to the middle third of the inguinal ligament.

- *Etiology*: Pressure or excessive flexion, e. g., in the context of hip surgery with an anterior approach or in osteotomy. Stretching of abdominal tissue due to obesity or pregnancy.
- *History*: Burning pain and paresthesia at the outer, anterior thigh. Symptoms are exacerbated by walking, standing, and lying down. Sitting, by taking the tension out of the inguinal ligament, relieves the pain.

- *Examination*: Paresthesia and hypesthesia at the anterolateral thigh. Relief comes from sitting. The diagnosis is secured by injecting local anesthetic at the entry point of the nerve (this offers immediate pain relief).

Sciatic Nerve Paresis (L4–S3)

Injury to the sciatic nerve, mostly at the buttocks. The peroneal nerve injury often dominates or is the only nerve that is damaged.

- *Etiology*: Mostly via faulty i.m. injection in the buttocks. Also in a context of trauma, e. g., in pelvic fracture, dislocation of the hip joint, and gunshot wounds. Iatrogenic following total hip arthroplasty.
- *History*: Insecure gait, e. g., directly following the injection or postoperatively, but also hours or days later. Sensory disorder at the foot.
- *Examination*: If the peroneal nerve is affected, foot and toe dorsiflexion is disturbed (power grade 4-0). Hypesthesia (Fig. 1.47). Hypesthesia between the first and the second toe, at the back of the foot and at the lateral distal lower leg (Fig. 3.49). Achilles tendon reflex can be elicited! In case of complete lesion of the nerve, foot plantar flexion is additionally disturbed, and hypesthesia is present at the calves and the sole of the foot. Active hip mobility and some knee flexion are still possible. Achilles tendon reflex is absent (Fig. 1.42).
- *Diagnostics*: Neurological consultation (electromyography, electroneurography, new or old damage, denervation, repair).
- *DD*: Peroneal paresis. Root lesion L5/S1.

Femoral Nerve Paresis (L1–L4)

Injury to the femoral nerve, mostly at the inguinal ligament or in the context of intrapelvic injury.

- *Etiology*: Retroperitoneal hematoma (e. g., under anticoagulation therapy). Surgical interventions (total hip arthroplasty). Trauma. Aneurysm of the abdominal aorta. Inflammatory processes at the hip joints.
- *History*: Noticed fairly quickly due to the inability to extend the knee.
- *Examination*: Weakness in knee extension and hip flexion (M4–M0; in intrapelvic injury). Solitary knee flexion weakness (M4–M0, in injury at the inguinal ligament). Hypesthesia at the anterior, at the internal thigh, at the internal-anterior lower leg, and at the medial foot (Fig. 3.49). Patellar tendon reflex is absent (Fig. 1.41).
- *Diagnostics*: Eventually neurological consultation (electromyography, electroneurography, new or old damage, denervation, repair).
- *DD*: Root lesion L3/L4.

3.3 Knee Joint and the Lower Leg

3.3.1 Systematic Examination

- **Local findings**

Gait	Inconspicuous/limping(right/left)	Painful limping, shortening limping, guarding limping, stiffening limping
Pelvic	Pelvic stance level/asymmetric/ compensated	Right/left (--cm)
Axes	Physiological/pathological: --degree (right/ left)	Genu valgum/varum Genu recurvatum Crus varum Rotation (external/internal)
	Intercondylar distance Malleolar distance	--cm (right/left)
Swelling/redness/ hyperthermia	None, if yes then:	Localization/extent/consistency/ Circumference (soft/firm/movable)
Hematoma/abrasion/ open wounds/scars	None, if yes then:	Localization/extent/circumference
	None, if yes then:	Location/extent/consistency (soft/ firm/movable)
Capsular swelling	None, if yes then (right/left):	Minimal/severe
Effusion	None, if yes then (right/left):	Minimal/firm/dancing patella
Muscles	Quadriceps femoris muscle/medial vastus muscle, knee flexors	Highly developed/wasted/ shortened Atrophy (significant?), muscle tone increase or decrease (right/left)
Circumference	20 cm above the medial joint space 10 cm above the medial joint space middle of the knee 15 cm above the medial joint space Lower leg's smallest circumference Malleoli Forefoot ball	--cm (right/left)
Mobility knee	Extension/flexion	--/--/--Degree (passive, right/left)
Mobility patella	Mobility	Hypermobile/normal/firm (right/ left)
	Mobility during flexion	Central/lateralized (right/left)
Crepitation	None; if yes: fine/rough (right/left)	Retropatellar/medial compartment/lateral compartment
Knee joint pain	Movement pain (direction, continuous/at maximal ROM). Pain upon moving patella. Zohlen's sign Tenderness to pressure: joint space (anterior/dorsal, medial/lateral), collateral ligament insertion site (femoral/tibial), femoral condyle, patellar facet, Apley distraction pain	None; if yes: positive (right/left)

Meniscus sign	Tenderness to pressure at the joint space (medial/lateral) Medial external rotation pain (Steinmann I)/ internal rotation pain, lateral tenderness in medial the joint space during flexion further posterior (Steinmann II) Adduction pain medial/abduction pain lateral (Böhler) Payr test Apley compression test Hyperflexion pain/hyperextension pain	Negative/positive (right/left)
Collateral ligaments	In the neutral position and at 30° flexion	Stable/increased lateral instability (medial/lateral; right/left)
Cruciate ligaments	In 90° flexion (in a neutral position, at 15° external rotation, at 30° internal rotation)	Stable/positive anterior translation of the drawer phenomenon (+/++/+++) (right/left)
	In 90° flexion	Stable/positive posterior translation in the drawer phenomenon (+/++/+++) (right/ left)
	Firm resistance when testing the drawer sign	Soft/hard
	Lachman's test Pivot-shift test	Negative/positive (right/left)
Amputation stump length	Internal knee joint space–end of the amputation stump	--cm (right/left)

- **Neurology**

Deep tendon reflexes	Quadriceps tendon reflex (L4) Posterior tibial reflex (L5) Achilles tendon (S1)	Right/left Vigorous/decreased/absent/supernormal (hyperreflexic)/cloni (right/left)
Sensory function	Dermatome (segment assignable/not exactly assignable)	Hypesthesia/paresthesia/dysesthesia (right/left)
Motor function	Knee flexion/hip adduction (L3) Knee extension/hip abduction (L4) Standing on the heels (foot and big toe dorsiflexors; L5, sciatic nerve, peroneal nerve). Standing on the toes (foot plantar flexors; S1)	Right/left intact/impaired function (M0–M1–M2–M3–M4–M5)

- **Perfusion**

Arteries	Popliteal artery Dorsalis pedis artery Posterior tibial artery	Fully/barely/not palpable (right/left)
Veins	Varicosis cruris Venous stasis Hyperpigmentation	None/present (right/left)
Capillary pulse	Tips of the toes	Visible/invisible

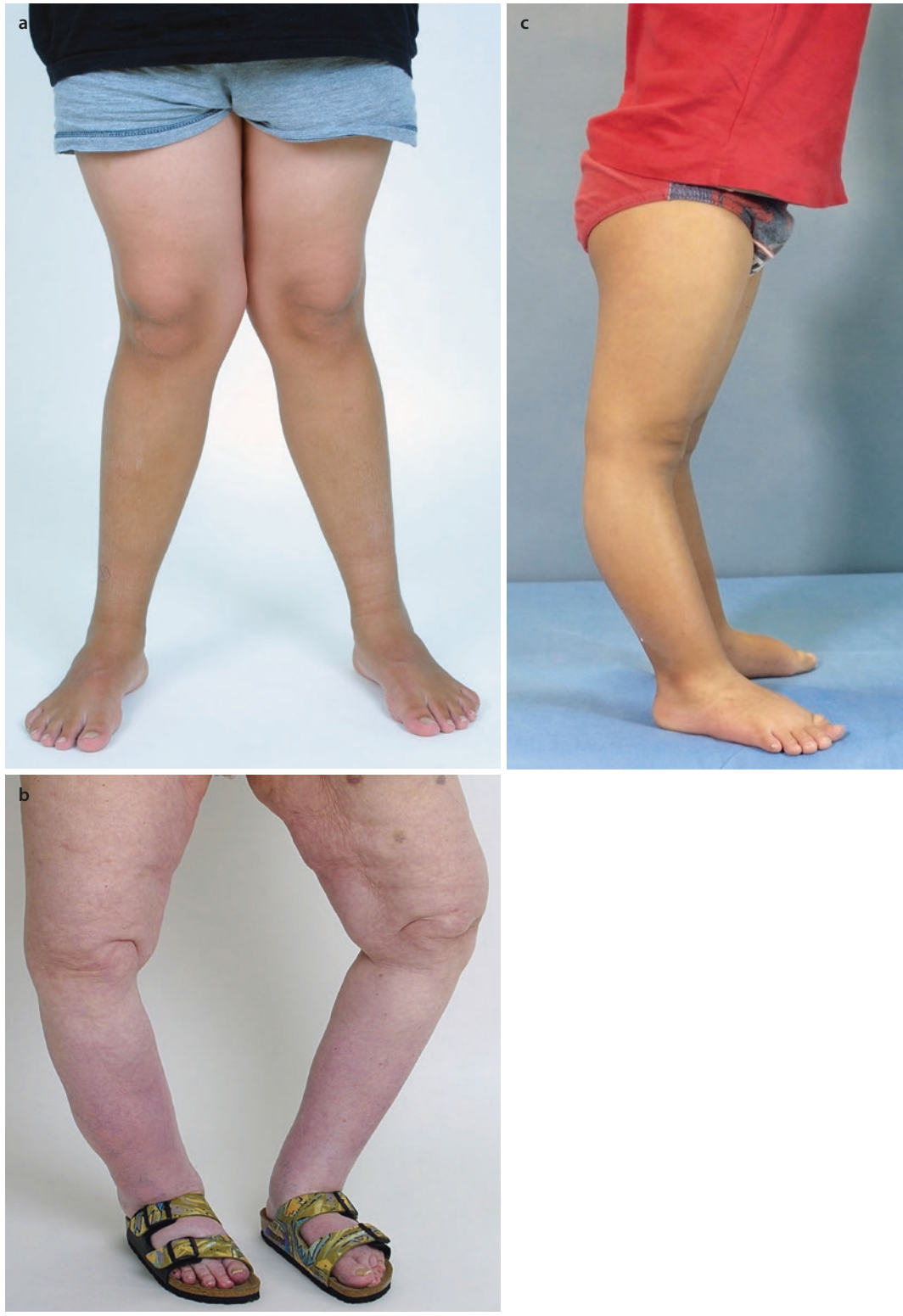


Fig. 3.15 (**a**, **b**, **c**) Genu valgum (**a**), genu varum (**b**), genu recurvatum (**c**)

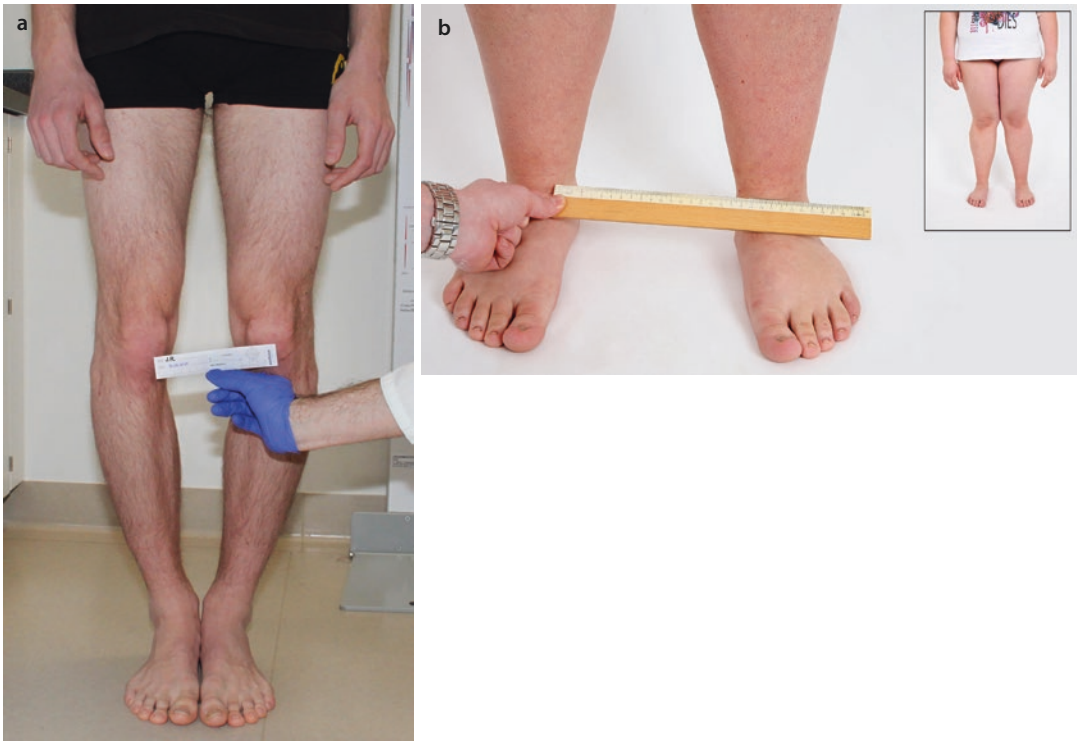


Fig. 3.16 (**a**, **b**) Measuring the intercondylar distance (**a**) and the malleolar distance (**b**). Both values are indirect indicators for deformity in the knee joint

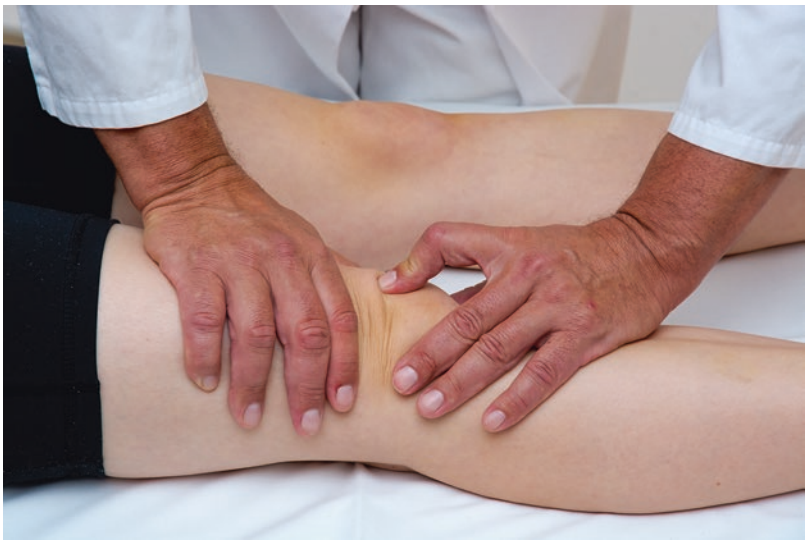


Fig. 3.17 Testing for knee joint effusion: the examiner uses a flat hand to squeeze the superior recesses in a distal direction (to concentrate the effusion on the small space). The examiner holds the patella, but does not fixate it. With the index finger of the opposite hand, in case of effusion, the patella can be squeezed down and jumps back ("dancing patella")

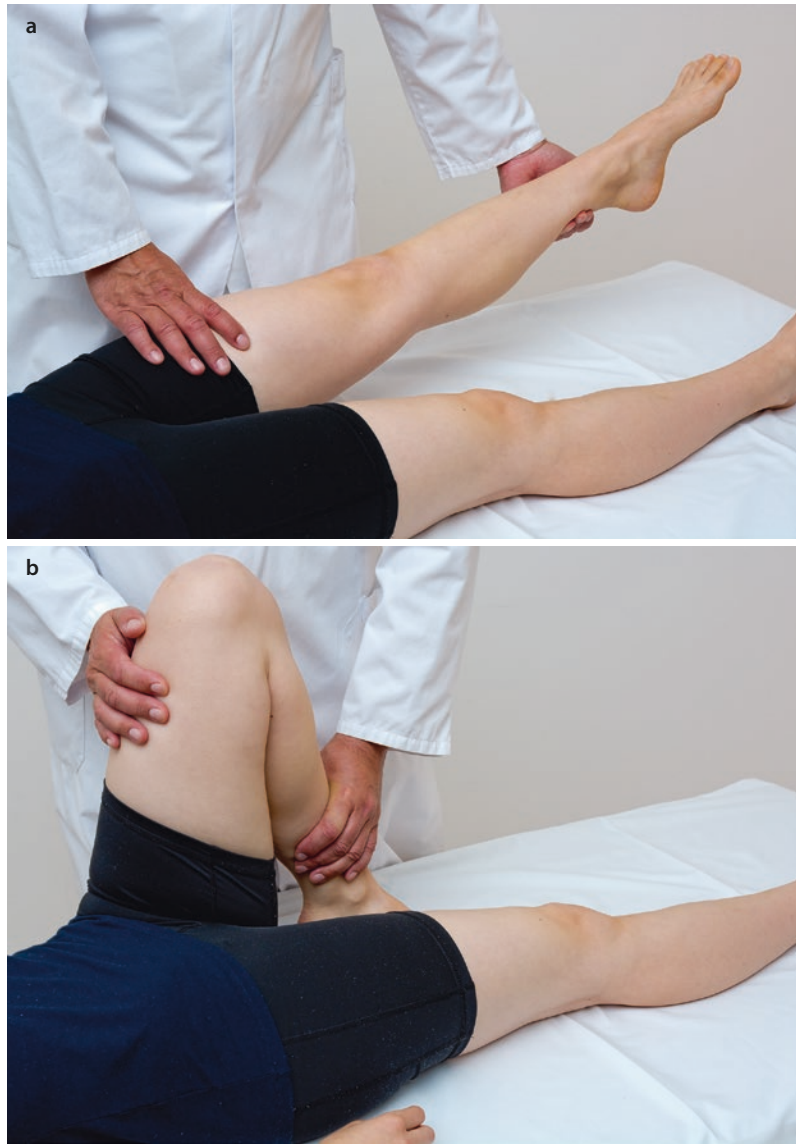


Fig. 3.18 (**a**, **b**) Testing extension/flexion in the knee joint. The knee is extended (**a**) and flexed (**b**). The normal range of motion is 5–10/0/120–150°

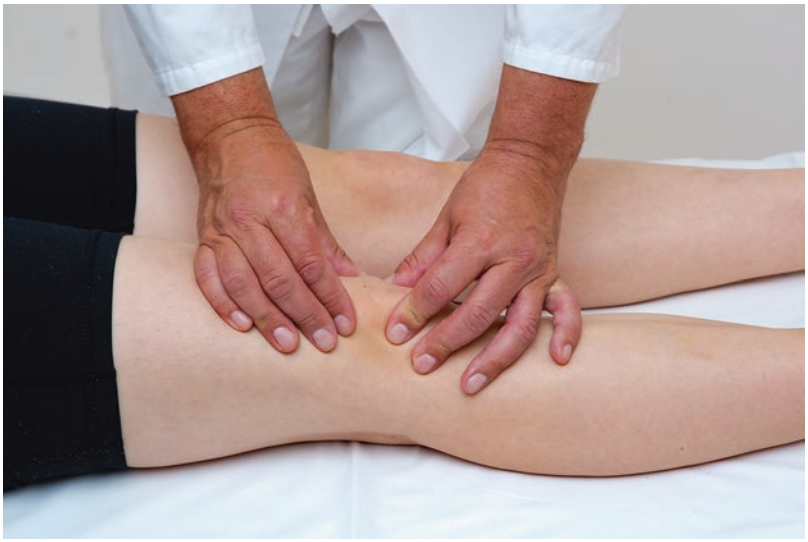


Fig. 3.19 Testing the tenderness to movement in the patella. The patella is fixed at the inferior and superior pole by the examiner's thumb and index finger. If retropatellar chondropathy is present, pain is reported upon shifting the patella in a medial or lateral position

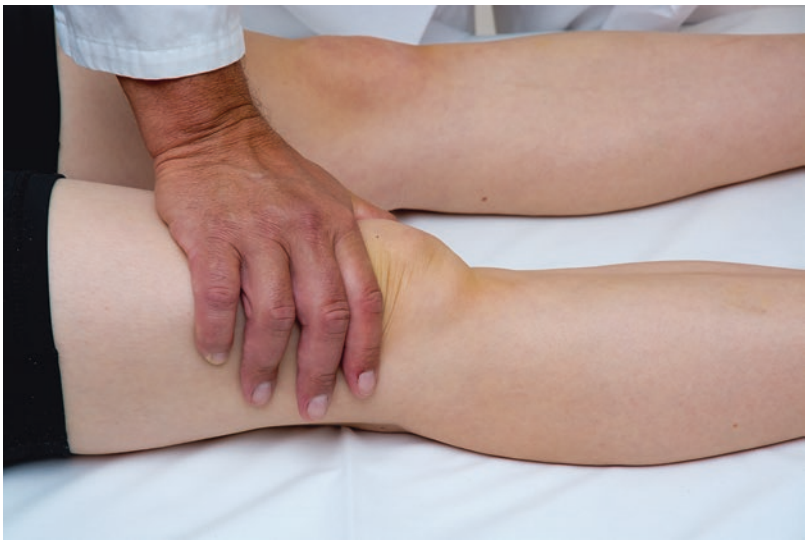


Fig. 3.20 Testing the Zohlen's sign: the examiner grips the patella from the front and fixates it with slight distal pressure. The sign characterizes retropatellar cartilage injury. It is positive if the patient reports retropatellar pain upon activation of the knee extensor muscles. The Zohlen's sign is often positive in healthy patients. A negative test suggests an absence of retropatellar cartilage injury

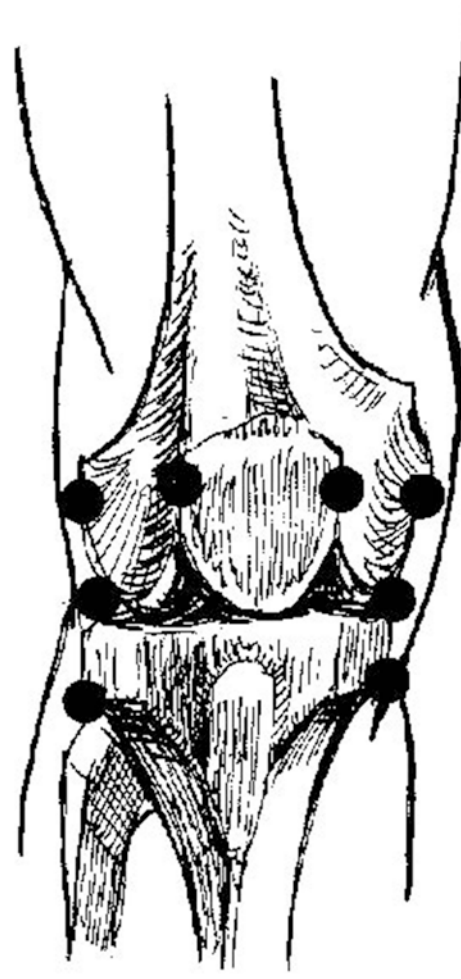


Fig. 3.21 Testing for tenderness at the knee joint: medial and lateral joint space (anterior/dorsal), medial and lateral collateral ligament (tibial and femoral), and medial and lateral facet of the patella. By applying pressure to the medial and lateral joint space, the meniscus can be tested. In case of meniscal tearing, pain can be elicited. Tenderness over the joint space can also be present in cases of collateral ligament injury. To differentiate this diagnosis, the examiner can pay attention to the patient reporting pain while testing the collateral ligaments. A ruptured collateral is painful when stretched, while a meniscus is painful under compression of the affected joint space. Further points of tenderness include the patellar facet and indicate injury in this region (chondropathy, plica mediopatellaris)

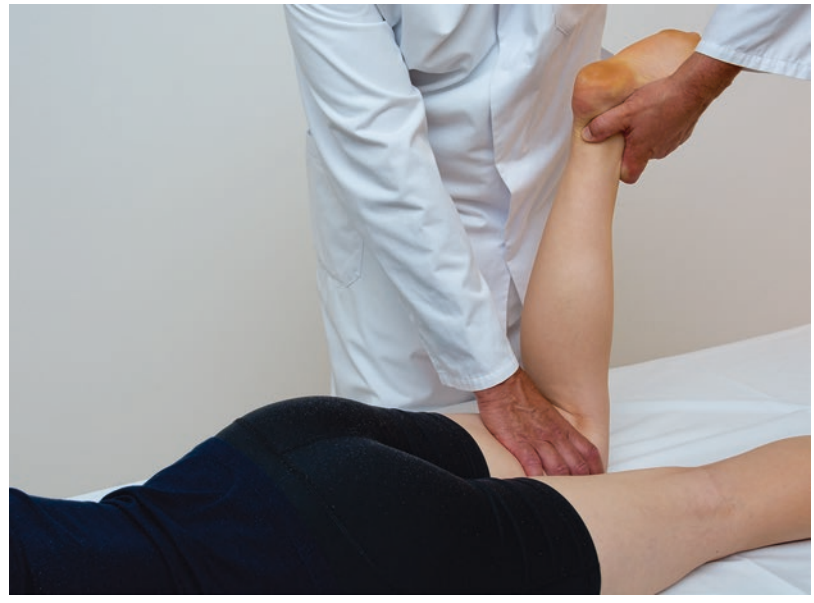


Fig. 3.22 Apley distraction test: the patient lies on his/her stomach; the examiner rotates the leg (that is bent into a 90° angle) externally and internally. If pain persists, a joint capsule lesion is likely. If a meniscal lesion is present, pain will not be elicited

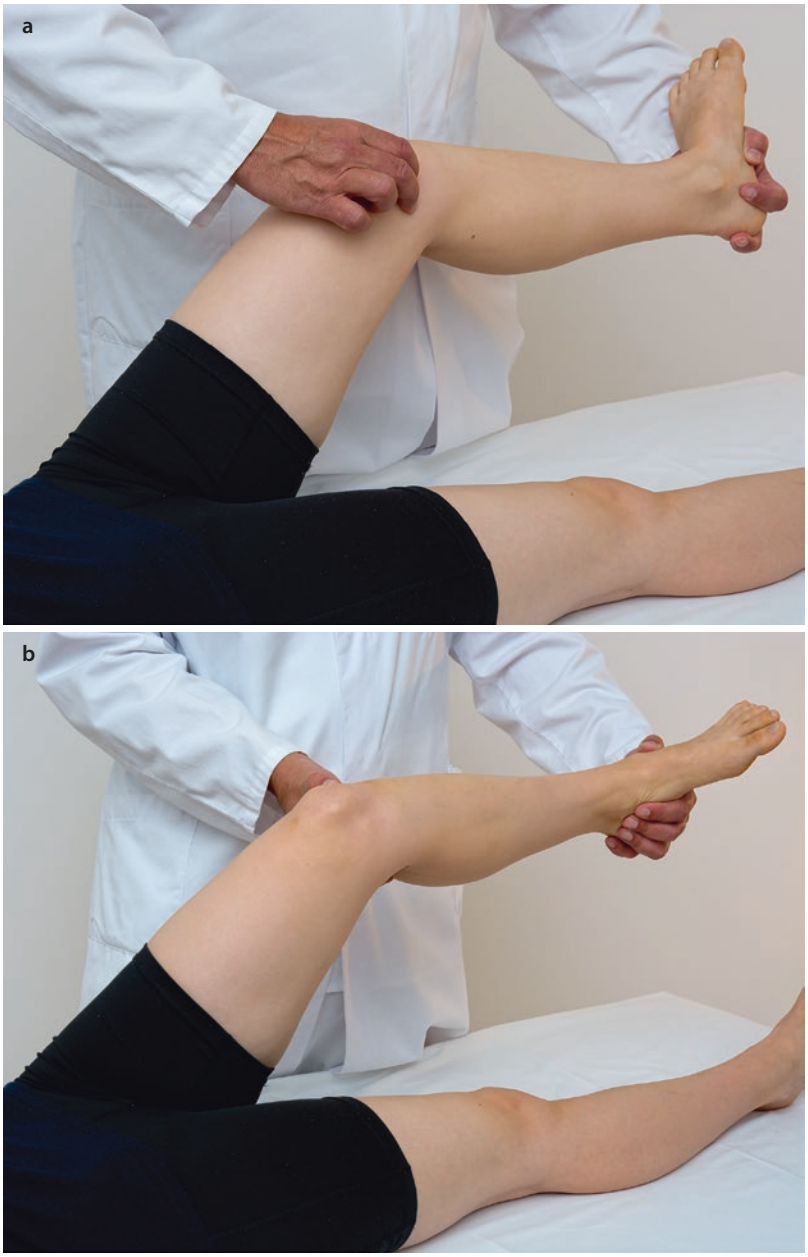


Fig. 3.23 (**a**, **b**) To test the internal meniscus, the lower leg is externally rotated while the knee is flexed. In case of internal meniscus tear, pain can be elicited (**a**). If the external meniscus is affected, pain is elicited by internal rotation (**b**) (Steinmann I)

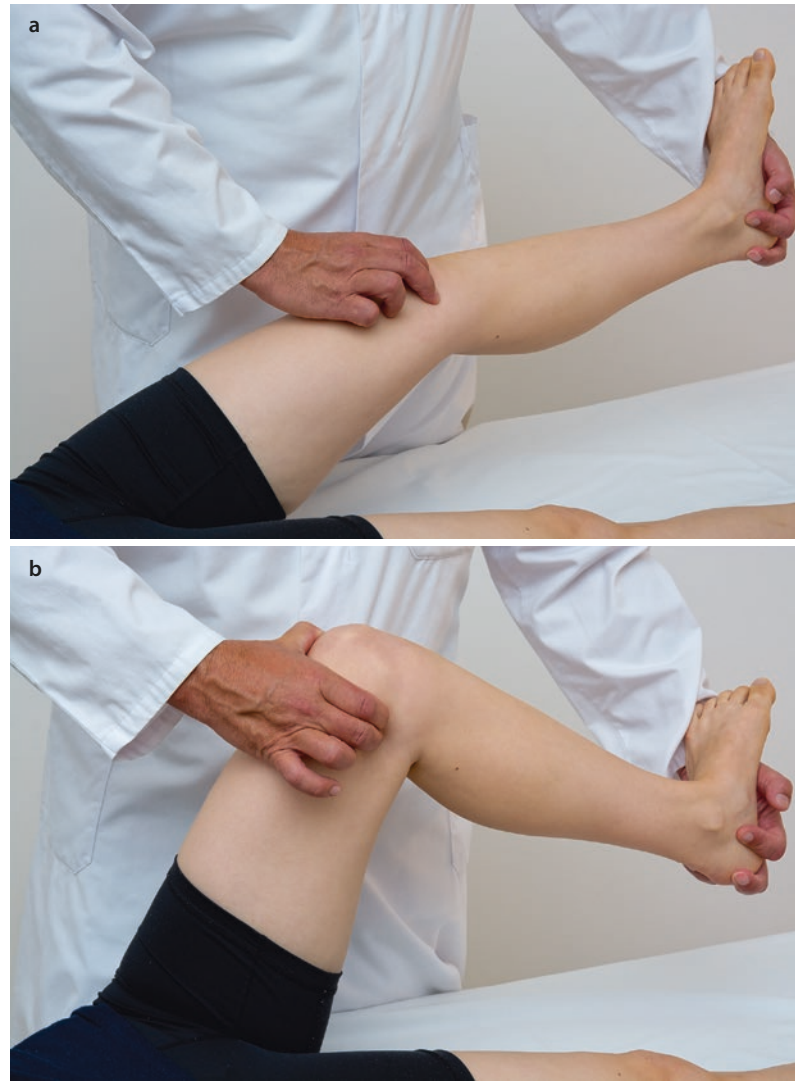


Fig. 3.24 (**a**, **b**) If tenderness at the medial joint space radiates (**a**) dorsally when flexing the knee (**b**), a lesion to the posterior horn of the internal meniscus is present (Steinmann II). This occurs because the menisci and the femur condyles move backward when the knee is flexed

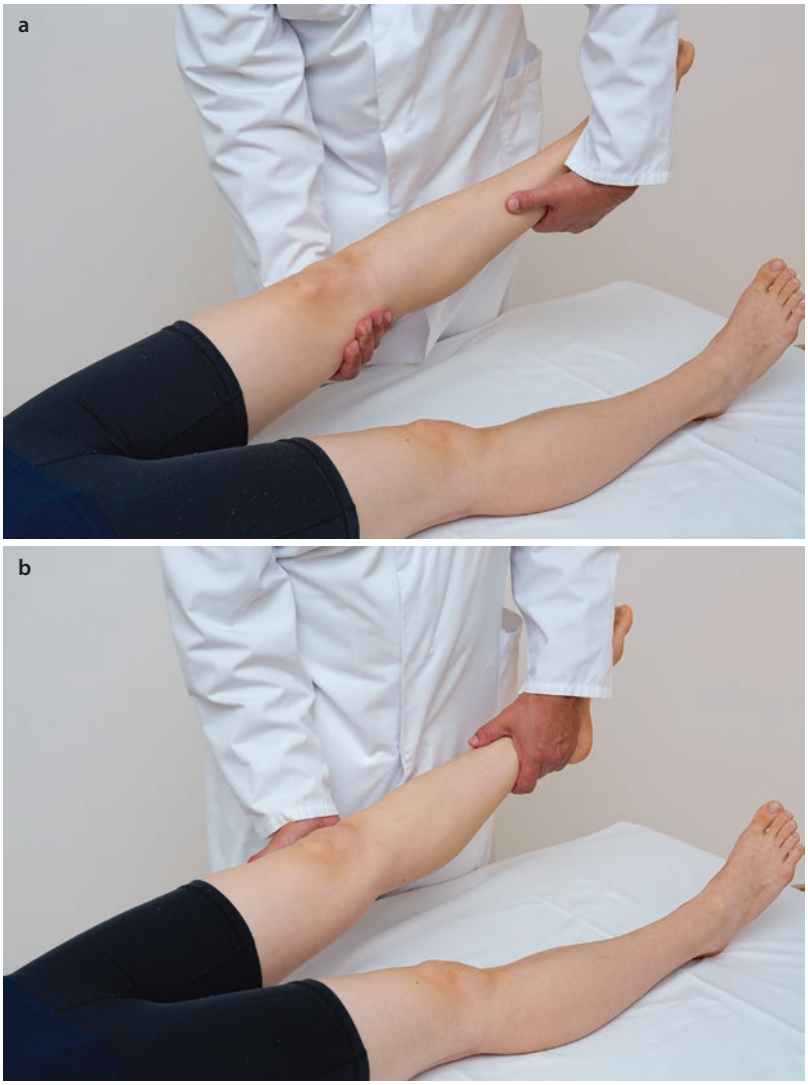


Fig. 3.25 Testing abduction pain: a medial adduction pain (**a**) indicates an internal meniscal lesion; lateral abduction pain (**b**) indicates a lesion to the external meniscus (Böhler's sign)

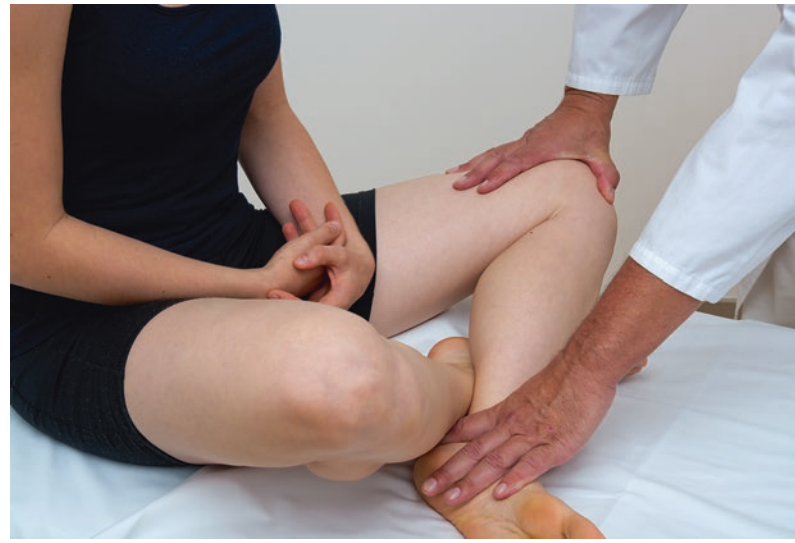


Fig. 3.26 Payr test: the patient sits with crossed legs. The examiner presses down on the affected knee joint. This leads to impingement of the internal meniscus. The test is positive if pain is reported at the medial joint space. This indicates a lesion to the internal meniscus

Fig. 3.27 (**a**, **b**) Apley compression test (Apley grinding test): the patient lies on his stomach, and the examiner presses the lower legs down and rotates the leg simultaneously inward and outward. If pain presents during external rotation, it indicates a lesion to the internal meniscus (**a**); if pain presents during internal rotation, it indicates lesion to the external meniscus (**b**)

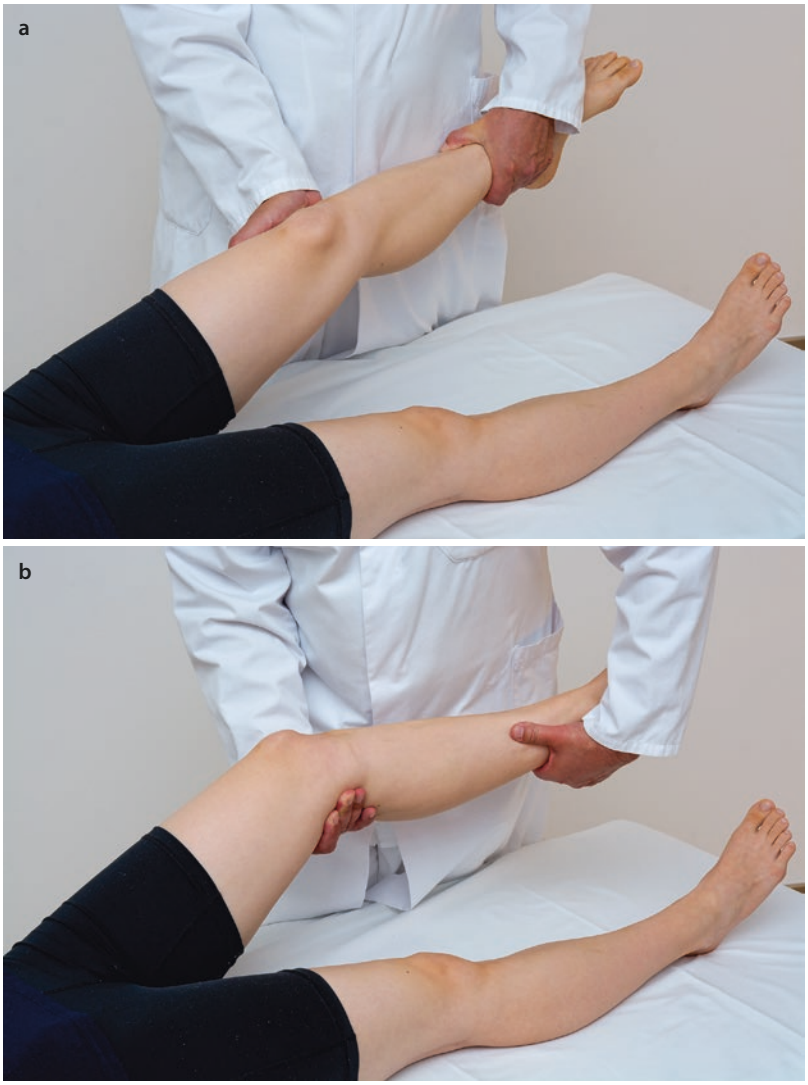


Fig. 3.28 (**a**, **b**) Testing the medial (**a**) and the lateral (**b**) expandability of the knee. The knee is held in slight flexion to eliminate the stabilizing effect of the posterior joint capsule. To test the internal ligament (medial collateral), valgus stress is exerted on the extended knee; to test the external ligament (lateral collateral), valgus stress is exerted. The lower leg lies on the lower arm of the examiner and is stabilized with the hand at the calf. The collateral ligament stability is subjectively classified into three grades (+, ++, +++). If the collaterals are healthy, a firm stop is sensed at maximum range of motion. In case of collateral insufficiency or collateral ligament rupture, medial and lateral expandability is increased under valgus or varus stress, and a softer movement stop is felt at maximum range of motion. Physiologically, very little sideward expandability of the medial or lateral ligaments is possible in the 20° flexed knee

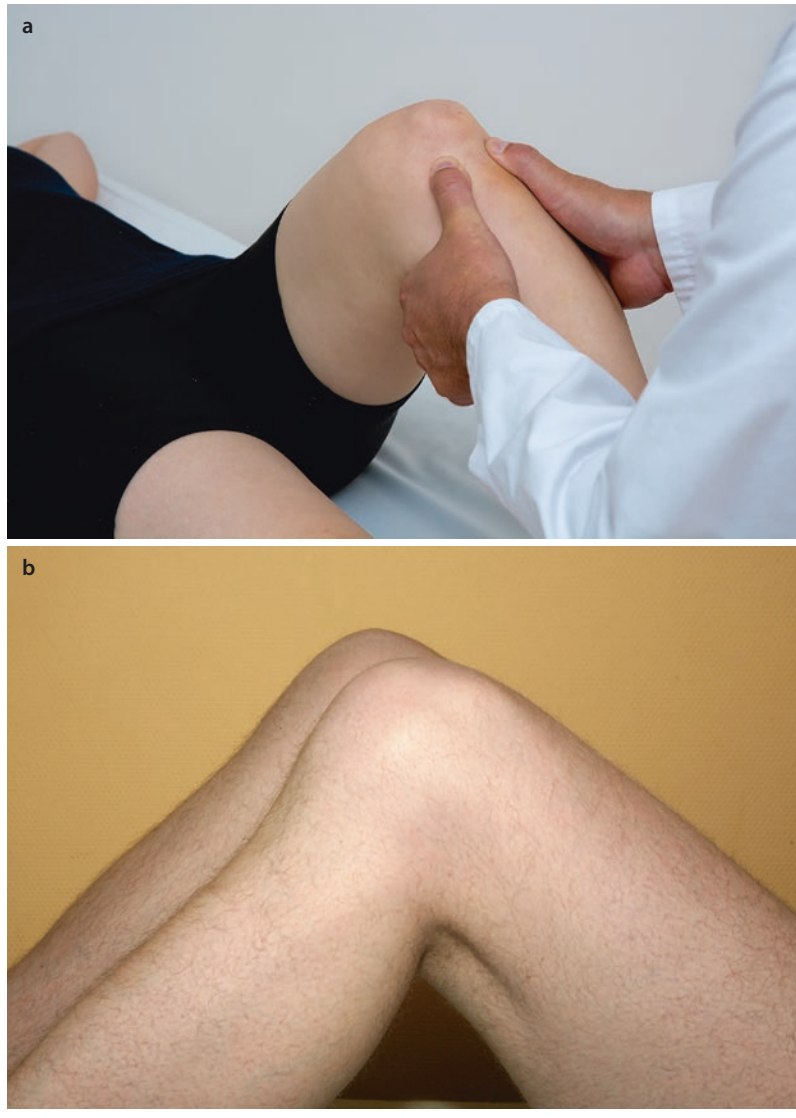


Fig. 3.29 (**a**) Drawer test: the test involves anterior and posterior translation of the tibia. The tibial head is held in both hand, and the tibia is moved backward or forward. The thumbs fixate the knee at the tibial tuberosity. In case the anterior cruciate is torn, increased anterior translation is possible; in case the posterior cruciate is torn, increased posterior translation is possible. Anterior translation, used to test the anterior cruciate, is quite inaccurate as the anterior movement of the tibia at a 90° angle is also limited by the secondary knee stabilizers (collateral ligaments, menisci, and dorsal capsular structures). The rotatory drawer allows the examiner to determine involvement of the capsule–ligament apparatus. A positive drawer test at external rotation indicates additional injury to the medial capsule–ligament apparatus; a positive test at internal rotation indicates additional injury to the lateral capsular–ligament apparatus. (**b**) Posterior Sag Sign: this sign allows the examiner to identify a posterior cruciate ligament tear or instability. The knee is flexed to 90° and the foot is placed on the examining table. Compared to the contralateral leg, gravity forces the tibial plateau to sink down in case of a ruptured cruciate ligament. This becomes clear via a decreased prominence of the tibial tuberosity of the affected side (Courtesy of Prof. Pierre Hepp, Leipzig)

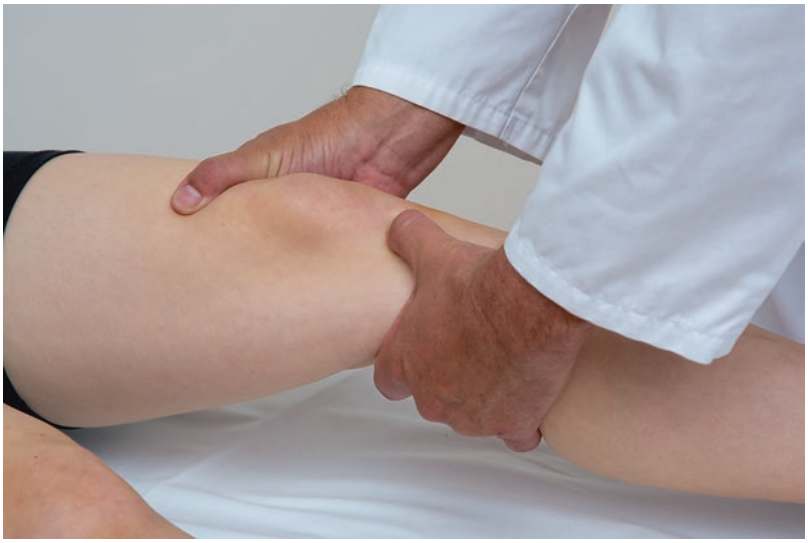


Fig. 3.30 Lachman's test: serves to test anterior cruciate ligament stability. It is a more sensitive test for the anterior cruciate ligament than the drawer test at 90° flexion. The test is performed with the knee flexed to 30°. One hand holds onto the medial tibial plateau, and the other hand holds onto the lateral thigh. The tibia is translated in an anterior direction, and the femur and the tibial head are thus moved in opposite directions. The test is valid as long as a limitation at maximal range of motion is sensed. A strong limitation at the maximal range of motion is physiological, and the examiner and the patient experience this as a rattle. In anterior cruciate ligament tear, a prolonged anterior movement of the tibia with soft limitation at maximal range of motion is sensed. The ventral translation of the tibia (anterior drawer) is subjectively graded in three grades (+, ++, +++) and must always be compared to the opposite side

Fig. 3.31 Pivot-shift test: pivot shift describes a sudden slippage of the central pivot of the joint and thus a displacement of the rotational center. If the medial collateral ligament and the iliotibial tract are intact, a positive pivot-shift phenomenon indicates an anterior cruciate ligament tear. The lower leg is held and internally rotated, while the other hand exerts valgus stress to the knee and the tibia. The knee is bent from the extended position. If the anterior cruciate is insufficient or ruptured, the lateral tibia subluxates in an anterior direction. In about 30° flexion, the iliotibial tract moves behind the flexion axis of the knee joint and becomes a flexor instead of an extensor. The tibia is abruptly relocated in orientation to the femur: the "pivot shift" with the snapping phenomenon visible for the patient and the examiner. This mechanism is often the cause of what patients report as the feeling of their knees "giving way" and collapsing. Be careful: the test should only be performed on relaxed patients with no pain, because a pain-induced muscular tension in the opposite direction can prevent subluxation of the tibial plateau

3.3.2 Leading Symptoms of the Knee and Lower Leg

The leading symptoms of the knee and the lower leg are summarized in Table 3.2.

Table 3.2 Leading symptoms of the knee and the lower leg

History	Pain	Local findings, functional tests	Sensory function disorder	Motor function disorder	Points to
Mostly young girls, no trauma	Pain at the patella, especially when descending a hill or stairs and after longer sedentary periods	Sometimes atrophy of the medial vastus muscle, patellar tenderness to pressure and to movement, Zohlen's sign positive, lateralization of the patella during flexion	None	None	*Femoropatellar pain syndrome*
Mostly women younger than 20, easily relocated recurrent dislocations of the patella without trauma	Barely any pain	Abnormal mobility of the patella, increased lateralization of the patella during flexion	None	None	*Habitual patellar dislocation*
Dislocation of the patella by twisting or falling, in the course of disease; this occurs more frequently and easily	Severe pain, especially following the first dislocations	Swelling, hematoma, dancing patella, tenderness at the medial patellar facet, in the course of disease increased lateralization of the patella during flexion	None	None	*Recurring patellar dislocation*
Adolescents, nonspecific pain, no trauma, impingement possible, swelling	Strain-dependent pain in the knee	Capsular swelling, eventually effusion, tenderness to pressure at the medial joint space, no rotation or adduction pain, eventually a palpable free-moving body in the upper recessus	None	None	*Osteochondrosis dissecans*

Standing up from the hunching position, slight rotation trauma, swelling of the knee joint, inhibited extension, or impingement	Strain-dependent pain or pain elicited by certain movements of the knee	Capsular swelling, effusion, tenderness to pressure at the medial joint space, external rotation pain, medial adduction pain	None	None	*Medial meniscal lesion*
Older rotation trauma (skiing downhill, soccer), sensation of "giving way," feeling of uncertainty and recurrent twisting, recurring swelling	Barely any	Capsular swelling, effusion and positive meniscal symptoms, anterior translation of the drawer sign positive, Lachman's test positive, pivot-shift test positive	None	None	*Older anterior cruciate ligament rupture*
Older lower leg fracture, either operated on or with conservative treatment	Continuous and cramp-like lower leg pain	Foot points downward, increasing soft tissue swelling, in the course of disease, firm tautened consistency of the muscles, pain aggravated by active and passive movement	May present in the course of disease	May present in the course of disease	*Compartment syndrome*
Mostly men, impingement swelling	Sharp pain during movement or strain	Capsular swelling, effusion, a palpable free-moving body in the joint, ROM limited	None	None	*Chondromatosis*
Age 50–60, eventually preexisting knee injury, increasing walking distance limitation, varus or valgus position of the knee	Pain in the knee following longer periods of rest, warm-up pain, in the course of disease, strain-dependent pain, and pain at rest	Painful limping, increased genu varum (valgum), capsule swelling, effusion, muscular atrophy at the upper leg, extension deficit, inhibited flexion, crepitation, Zohlen's sign positive	None	None	*Gonarthrosis*

(continued)

Table 3.2 (continued)

History	Pain	Local findings, functional tests	Sensory function disorder	Motor function disorder	Points to
Mostly older patients, e.g., preexisting rheumatoid arthritis or beginning gonarthrosis, sensation of pressure or tension in the popliteal fossa	Tightening pain in the popliteal fossa	Palpable, firm swelling at the popliteal fossa	None	None	*Popliteal cyst* (*Baker's cyst*)
Recurrent swelling of the knee joint, preexisting enteric or urogenital infection, tick bite	Barely any	Slight capsule swelling and hyperthermia, effusion, muscular atrophy	None	None	*Reactive arthritis*
Knee puncture, operation, tonsillar angina, knee swells and is warm to touch, reduced general condition, fever, shivering	Severe knee pain	Painful limping, severe swelling, redness, hyperthermia, dancing patella, mobility severely impaired by pain	None	None	*Bacterial gonitis*
Infant or toddler, conspicuous bend in the lower leg on one side	Barely any	Varus bend at the lower leg in the distal third, sometimes localized tenderness to pressure at the bend	None	None	*Crus varum congenitum*
Child (2–4 years), increasing varus of the lower leg	Barely any	Genu varum with the bend close to the knee joint	None	None	*Blount's disease*
Surgery at the hip or knee, cast at the upper leg or lower leg, dorsiflexion of the foot impossible	Pain at the part with severe compression	Drop foot. Steppage gait. Achilles tendon reflex is still present	Hypesthesia between the first and second toe, at the back of the foot, and at the lateral distal lower leg	Foot and big toe dorsiflexor weakness	*Peroneal nerve paresis/common fibular nerve paresis*

3.3.3 Disorders of the Knee Joint and the Lower Leg

- **Clinical disorders**

■ *Acquired Contracture*

Movement impairment of the knee joint. In the form of flexion contracture limited extension and limited flexion with fibrous and bony ankylosis (stiffening).

- *Etiology*: Post-traumatic, postoperative, following acute and chronic inflammation, after long periods of immobility, Sudeck's disease, hemophilia, rheumatoid arthritis, and advanced gonarthrosis.
- *History*: Especially functional impairment.
- *Examination*: In flexion contracture, functional leg shortening and compensatory equinus position of the foot. Often associated with atrophy of the muscles of the upper leg. Range of motion is limited, and movement is associated with a hard, soft, or bouncy impact when moving. The mobility of the patella is severely limited.
- *Diagnostics*: X-ray of the knee in two planes (to rule out bone damage).
- *DD*: All etiologically relevant disorders.

■ *Femoropatellar Pain Syndrome*

Pain at the patella. The cause is chondromalacia of the retropatellar cartilage (grade I–IV according to Outerbridge). Pain correlates with the grade of chondromalacia.

- *Etiology*: Multifactorial. Bipartite patella, valgus deformity, muscular insufficiency of the medial vastus muscle, ligament weakness, and excessive strain.
- *History*: Mostly in adolescents, more common in girls. Pain at the patella (often bilateral) when descending stairs or walking downhill. Also following longer sitting (cinema, driving).
- *Examination*: Atrophy of the medial vastus muscle. Tenderness at various points of the patella (◘ Fig. 3.21), tenderness to movement in the patella (◘ Fig. 3.11), and Zohlen's sign positive (◘ Fig. 3.20). Increasing lateralization of the patella during flexion. Crepitation is possible.
- *Diagnostics*: X-ray of the knee joint in two planes (to rule out pathological changes to the bone). Defilé imaging of the patella (tangentially in 30, 60, and 90° flexion; shows possible lateralization in flexion).
- *DD*: Plica syndrome. Bipartite patella.

■ *Plica Syndrome*

Retropatellar and medial parapatellar pain syndrome, associated with hypertrophy and fibrosis of the plica mediopatellaris. Can lead to injury at the femoral and patellar cartilage.

- *Etiology*: Entrapment of the plica mediopatellaris between the femur condyle and the medial patella.
- *History*: Retropatellar pain and pain located medial to the patella. Snapping medial to the patella when standing up or sitting is possible.
- *Examination*: Nonspecific. Eventually palpable subcutaneous cord at the medial patella, tenderness at the medial patella (◘ Fig. 3.21), and eventually positive Zohlen's sign (◘ Fig. 3.20).
- *Diagnostics*: X-ray of the knee joint in two planes (to rule out pathological changes to bone). Defilé imaging of the patella (tangentially in 30, 60, and 90° Flexion; visualizes the possible lateralization in flexion).
- *DD*: Femoropatellar pain syndrome. Bipartite patella.

■ *Genu Recurvatum*

Knee capable of hyperextension.

- *Etiology*: Ligamentous laxity. Mostly acquired: Trauma (injury to the ventral proximal tibia epiphysis, malpositioned fractures), inflammation, and tumors. Neurogenic (poliomyelitis). Compensatory: leg shortening on the contralateral side and equinus.
- *History*: Knee joint can be hyperextended. Instability when standing or walking.
- *Examination*: Knee joint can be hyperextended (◘ Fig. 3.15). Normal range of motion and extension clearly increased beyond 5–10°.
- *Diagnostics*: X-ray of the knee joint with the lower leg in two planes (to rule out pathological changes to bone, examining the knee joint axes).

■ *Genu Varum/Genu Valgum in Children*

Unilateral or bilateral deformity of the legs involving a bow shape or an X shape. Newborn babies have a physiological genu varum until the age of 2 and beyond. This is followed by a physiological genu valgum until around the age of 7, eventually reduced by 5–7°. Pathological deformity of the leg axes can occur unilaterally or bilaterally.

- *Etiology*: Pathological deformity of the leg axes. *Bilateral*: In rickets, phosphate diabetes, achondrodysplasia, and osteogenesis imperfecta

Unilateral: Idiopathic, injury to the growth plates due to trauma, inflammation, or tumors. Blount's disease, paralysis, compensatory (in a context of hip adduction contracture).

- *History*: Deformity is in the foreground. Pain is rare.
- *Examination*: Leg axes are changed to either increased varus or valgus (Fig. 3.15). Intercondylar or intermalleolar distance is increased (Fig. 3.16). In genu valgum, a bilateral combination of foot deformity (pes planus, pes transversoplanus) is also found (Fig. 3.33).

Compartment Syndrome in the Lower Leg

Severe swelling in the muscles within the fascia, associated with disturbed microcirculation, interstitial edema, and pressure, increases in the compartments. At the lower leg, there are four compartments: anterior, fibular, superficial dorsal, and profound dorsal compartment. Associated with increasing functional impairment. Left untreated, compartment syndrome leads to necrosis of the muscles.

- *Etiology*: Fractures, massive metal implants, very tight fascia sutures, hemorrhage (anticoagulants, blood vessel injury), edema caused by contusion, too-tight dressing, casts, professional sports, marching.
- *History*: Swelling and pain (continual and cramp-like). Sensory disorder (late symptom!), functional impairment in the course of disease.
- *Examination*: Slight equinus. Local soft tissue swelling in the affected compartments. In course, taut, hard consistency in the muscles. Pain is aggravated by active movement against resistance and in passive flexion of the muscles. Peripheral pulses are mostly palpable. Sensory and motor function losses follow.

Peripheral neurovascular status must be checked and documented regularly in order to identify compartment syndrome early on!

- *Diagnostics*: Percutaneous tissue pressure measuring.
- *DD*: Deep lower leg venous thrombosis. Peroneal paresis. Acute arterial occlusion in peripheral artery disease.

Sudeck's Disease (Algodystrophy, Complex Regional Pain Syndrome)

Painful dystrophy of the extremities with regionally disturbed perfusion and atrophy of the soft tissue and the bones.

- *Etiology*: Following fractures or surgery. Localized inflammation including psychological factors. Idiopathic in 20 % of cases.
- Type I: Sudeck's atrophy or algoneurodystrophy (trauma, no demonstrable nerve lesions).
- Type II: Causalgia (trauma, evidence of obvious nerve damage).
- *History*:

  Acute stage I: Inflammatory phase with hyperemia. Edema in the skin, pain at rest and upon strain.

  Subacute stage II: Dystrophy phase. After 2–4 months. The swelling recedes. Subcutaneous atrophy. Shrinking of the joint capsule and the ligaments.

  Chronic stage III (*end stage*): Atrophy phase. After 3–6 months. Atrophy of the skin, subcutis, and skeletal bones. Severe reduction in mobility, contracture.
- *Examination*:

  Acute stage I: The feet and the lower leg are swollen with edema; the skin is livid, glossy, and warm. The skin appears stretched. Pain at rest and during movement.

  Subacute stage II: Swelling recedes. Pale, cool skin. Mobility in the ankles is limited or lost.

  Chronic stage III (*end stage*): In comparison to the opposite side, clear atrophy in the lower leg. Mobility in the ankle is limited.
- *Diagnostics*: X-ray of the lower leg and the foot in two planes (decalcification, diffuse signs). Blood tests (cross-links are elevated in urine).

Patellar Dislocation

Chronic recurring dislocation of the patella, mainly in a lateral direction. One distinguishes between habitual and recurring dislocation.

- *Etiology*: Rarely congenital. Traumatic (rarely acute, as spontaneous relocation often happens). Rupture of the medial retinaculum following dislocation. Form deviations of the patella and the femorotibial joint (patellar dysplasia, dysplasia of the condyles, genu valgum, genu recurvatum, pathological femur antetorsion, lateralization of the tibial tuberosity) and the extensors (ligament laxity, patella alta). Atrophy of the medial vastus muscle.
- *History*: More common in women than men. The first dislocation mainly before the age of 20, mostly bilateral. In habitual dislocation, the patella dislocates slightly and does not cause any complaints. This dislocation can easily be

relocated. In recurring dislocation, a sudden twist in the legs and fall during a rotational movement elicits a sharp pain. Relocation is painful. The patella subsequently dislocates much easier and more often. It can be relocated by the patient him or herself or it occurs spontaneously.

- *Examination*:
  Habitual dislocation: Abnormally severe mobility in the patella. Increased lateralization of the patella with increasing flexion. Can lead to lateral subluxation or dislocation. Possible additional findings: Patella alta, genu valgum (Fig. 3.15), weak medial vastus muscle.
  Recurring dislocation: Swelling, eventually hematoma, effusion (Fig. 3.17). Severe tenderness at the medial patella (Fig. 3.21). In the course of disease, increased lateralization of the patella in flexion and medial tenderness at the patella (with secondary degenerative changes to the knee joint).
- *Diagnostics*: X-ray of the knee joint in two planes (to rule out changes to the bone). Defilé imaging of the patella (tangentially in 30, 60, and 90° flexion; visualizes possible lateralization in flexion, patellar dysplasia, or small osseous fragments.)
- *DD*: Habitual or recurring patellar dislocation.

Meniscal Lesions

Meniscal tears can be a longitudinal tear, horizontal tear, flap tear, and radial tear. Mainly affects the posterior horn of the internal meniscus, followed by the intermedial part and the external meniscus.

- *Etiology*: In 50 % degenerative, in about 40 % secondarily traumatic (often in combination with a cruciate ligament lesion), and only 8 % primarily involving trauma.
- *History*: Men are more commonly affected than women. Pain often sets in slowly or when getting up from a sitting or hunching position, following rotation or other trauma. Following trauma, swelling of the knee sets in very soon. Extension is limited; palpable snapping can be found in the knee. Entrapment signs or blockage (can often be solved by shaking, turning, and careful movement of the knee joint).
- *Examination*: Capsule swelling, effusion (Fig. 3.17). If the condition has existed longer, atrophy of the medial vastus muscle may exist. Pain during hyperextension (affects the anterior horn). Pain during hyperflexion (affects the anterior horn). *Medial meniscus lesion*: Tenderness to pressure at the medial knee joint (Fig. 3.21). This is present in a lesion of the internal meniscus' posterior horn, during flexion further posterior than during extension (Fig. 3.24. Steinmann II). Medial external rotation pain (Fig. 3.23, Steinmann I). Medial adduction pain (Böhler) (Fig. 3.25). Apley compression test in external rotation is positive (Fig. 3.27), rotation of the knee bent to a 90° angle with the patient lying on his/her stomach with simultaneous exertion of pressure. Payr positive (Fig. 3.26), pain at the medial knee when pressure is exerted on a patient's knees when he or she is sitting in a cross-legged position. *Lateral meniscus lesion*: Tenderness to pressure at the lateral knee at the height of the lesion (Fig. 3.21). Pain during internal rotation (Fig. 3.23). Lateral abduction pain (Fig. 3.25). Apley compression pain during internal rotation is positive (Fig. 3.27).
- *Diagnostics*: X-ray of the knee in two planes and of the patella (visualizing the joint space, the joint surfaces). MRI (if the symptoms are not clear).
- *DD*: Chondropathy, early gonarthrosis, and Ahlbäck's disease. In case of entrapment: Plica syndrome, chondromatosis, osteochondrosis dissecans, and partial anterior cruciate rupture.

Meniscal Ganglion Cyst

Ganglion cyst at the base of the meniscus. Often in combination with a meniscal lesion close to the base of the meniscus. Mostly at the external meniscus.

- *Etiology*: Metaplasia of mesenchymal cells. Meniscal malformation and lesions. Nutritional disorders and excessive strain.
- *History*: Mostly affects men between 30 and 40. Localized pain and circumscribed swelling of an alternating extent.
- *Examination*: Palpable (mostly visible), firm, and elastic tumor at the joint space, localized tenderness, often positive meniscal symptoms.
- *Diagnostics*: X-ray of the knee and the patella in two planes (visualizing the joint spaces, the joint surfaces). Sonography (extent). MRI (if symptoms are nonspecific).

- **Congenital malformation and metabolic disorders**

Congenital Pseudoarthrosis of the Tibia

Abnormal bowing of the lower leg in the middle and lower third. The condition is either congenital or develops within the first year of life. In course, it is associated with pseudoarthrosis in this area and can be unilateral or bilateral.

- *Etiology*: Sporadic, but also increased familial prevalence. In neurofibromatosis up to 10%. Circumscribed disturbed ossification and localized disturbed collagen formation. Pseudoarthrosis can be spontaneous or following medical procedures or surgery.
- *History*: Conspicuous bowing of the lower leg, mostly unilateral. Walking sets in later and with a disturbed gait.
- *Examination*: Relatively typical is the one-sided bowing of the lower leg at the distal third of the tibia combined with an anterior bowing and leg shortening. In case of pseudoarthrosis, localized tenderness and instability of the fragments may be present.
- *Diagnostics*: X-ray of the lower leg in two planes (to visualize deformity and pseudoarthrosis or for differential diagnosis). MRI (if symptoms are nonspecific).
- *DD*: Rickets, syphilis, and osteogenesis imperfecta.

Bipartite Patella

Congenital splitting of the patella. In the majority of cases, presents as bipartite patella with the second, smaller part located in the lateral upper quadrant. May also present as patella tripartita or multipartita (up to six segments possible).

- *Etiology*: Probably malformation based on disturbed inhibition.
- *History*: Mostly an incidental finding, e.g., in femoropatellar pain syndrome.
- *Examination*: Patellar facet tenderness, positive Zohlen's sign, pain upon moving the patella, and crepitation (Figs. 3.19, 3.20, and 3.21).
- *Diagnostics*: X-ray of the knee in two planes and of the patella (to visualize the patella).
- *DD*: Femoropatellar pain syndrome. Plica syndrome.

Discoid Meniscus

Disc shape of the meniscus, involving almost the complete joint space. It almost exclusively affects the lateral meniscus.

- *Etiology*: Possible disturbed inhibition during embryonic development.
- *History*: No difference in prevalence between the sexes. Complaints only manifest in the second decade of life. Pain and snapping at the knee or clicking during walking or running. A feeling of instability is common. Entrapment is possible.
- *Examination*: Relatively nonspecific. Tenderness to pressure over the lateral joint space (Fig. 3.21) and snapping during movement is possible.
- *Diagnostics*: X-ray of the knee joint in two planes and of the patella (to rule out pathological changes to bone). MRI (if symptoms are nonspecific).
- *DD*: Meniscal lesion. Plica syndrome.

M. Ahlbäck

Avascular necrosis of the medial femur condyle in older age.

- *Etiology*: Primary (idiopathic). Secondary after local or systemic steroid (cortisone) treatment. Disturbed circulation in cardiovascular disorders, hyperlipidemia, hyperuricemia, and diabetes.
- *History*: Rare disorder, mostly seen in women over 60. Sudden pain at rest and upon strain at the medial joint space. No history of trauma. Limited walking distance due to pain.
- *Examination*: Limping gait, in advanced disease, genu varum (Fig. 3.15). Tenderness at the medial joint space (Fig. 3.21). Limitation of range of motion (Fig. 3.18).
- *Diagnostics*: X-ray of the knee joint in two planes with patient standing on one leg, including the patella (to visualize osteonecrosis, differential diagnosis). Scintigraphy (increased accumulation). MRI (extent of necrosis).
- *DD*: Degenerative meniscal lesion. Osteochondrosis dissecans (in younger patients). Primary or secondary medial gonarthrosis.

Osgood–Schlatter Disease

Avascular necrosis of the tibial apophysis with a typical course of disease.

- *Etiology*: Strong traction on the patellar ligament, e. g., in the context of sports.
- *History*: Mostly boys aged 10–16. Slight pain at rest, exacerbated by exertion (when ascending stairs or during sports: soccer or sports involving jumping).

- *Examination*: Swelling and redness at the tibial tuberosity, localized tenderness, and pain exacerbated by extension of the knee against resistance.
- *Diagnostics*: X-ray of the knee joint in two planes (to visualize the necrosis at the tibial tuberosity).

Sinding-Larsen's Disease

Avascular necrosis of the inferior pole of the patella.

- *Etiology*: Unknown.
- *History*: More common in boys than girls. Mostly age 10–14. Diffuse pain at the knee or localized pain at the patella when ascending stairs or in sports involving jumping. In the course of disease, limited flexion and atrophy of the upper leg muscles.
- *Examination*: Localized tenderness to pressure, pain exacerbated by knee extension against resistance, and painful limitation of flexion. Atrophy of the upper leg muscles compared to the opposite leg. Sometimes swelling at the patellar pole.
- *Diagnostics*: X-ray of the knee joint in two planes and of the patella (to visualize necrosis, for differential diagnosis).
- *DD*: Meniscal lesions. Plica syndrome. Femoropatellar pain syndrome. Bipartite patella.

Osteochondritis Dissecans

Avascular necrosis of the subchondral bone leading to detachment of bone and cartilage. Fragments of the bone and cartilage move freely in the joint space. Mostly affects the medial femoral condyle of the knee joint, less commonly the lateral and the posterior surface of the patella. In 10–30 % bilateral.

- *Etiology*: Unclear. Some theories: Ischemia, disturbed ossification of the epiphysis, singular trauma, repeated microtrauma, strain, constitutional, or hereditary disposition.
- *History*: Mostly shortly before growth is completed. Commonly an incidental finding in X-ray. Complaints are often nonspecific: Difficult to locate strain-dependent knee pain. Furthermore, swelling and effusion. Sudden impingement is common if free-moving bony or cartilage fragments are present.
- *Examination*: Increased circumference of the leg at the medial knee joint space as well as effusion. In some cases, tenderness at the medial joint space. In some cases, the free-moving lesion of the cartilage or bone can be palpated in the joint space.
- *Diagnostics*: X-ray of the knee joint in two planes and of the patella (to show necrosis, differential diagnosis). Eventually MRI (extent of the necrosis).
- *DD*: Meniscal lesion. Plica syndrome. Femoropatellar pain syndrome. Bipartite patella.

Blount's Disease (Tibia Vara)

Osteochondrosis of the proximal, medial tibial epiphysis, and metaphysis. The growth deficit leads to varus of the tibia.

- *Etiology*: Localized form of epiphyseal dysplasia (endochondral dysostosis). Avascular necrosis of the medial part of the proximal tibial epiphysis is being discussed.
- *History*: Manifests in the second to fourth year of life (infantile form, more common), from the fourth to the tenth year of life (the less common juvenile form), and from age ten onward (adolescent form). Common in Africa, in Finland, and in Jamaica. Commonly unilateral, in some cases bilateral with increasing varus of the lower leg.
- *Examination*: Genu varum with the inward angle of the lower legs just below the knee (Fig. 3.15). Shortening of the lower leg (mostly in the infantile form). Combination with internal rotation defect and genu recurvatum is possible.
- *Diagnostics*: X-ray of the knee joint with the lower legs in two planes (to visualize the necrosis and determine the axes, differential diagnosis).
- *DD*: Physiological varus. Congenital pseudoarthrosis of the tibia. Chondrodystrophy. Rickets. Osteogenesis imperfecta. Inflammation, trauma, and tumor.

- **Degenerative disorders**

Gonarthrosis

Degenerative disorder of the knee joint. Often silent for many years (latent gonarthrosis) and then followed by flares (active gonarthrosis). Can present as varus or valgus gonarthrosis. Can affect all compartments (pangonarthrosis) or isolated to the femoropatellar joint (retropatellar arthrosis).

- *Etiology*: Primary (idiopathic). Secondary: traumatic injury to the cartilage, the bone, menisci, and the ligaments. Inflammation (nonspecific and rheumatic). Avascular necrosis (e. g., Ahlbäck's disease). Metabolic disorders (chondrocalcinosis, gout, hemophilia). Immobilization.
- *History*: Primary gonarthrosis especially in old age, secondary gonarthrosis can also present earlier. Initially nonspecific joint pain followed by pain after periods of rest and warm-up pain. Pain at rest and upon strain and nocturnal pain. Morning stiffness of less than 30 min, reduced walking distance. Increasing deformity of the legs and limited range of motion. Atrophy of the upper leg muscles. Swelling at the knee joint.
- *Examination*: Limping gait. Knee contours increasingly coarsened. Eventually increased circumference of the leg. Increasing varus or valgus deformity of the knee axes (Fig. 3.15), including increased medial and lateral laxity. Atrophy of the upper leg muscles. Positive Zohlen's sign (Fig. 3.20). Limitation of mobility, eventually flexion contracture. Reduced circumference of the upper leg compared to the opposite side. Possibly a palpable popliteal cyst in the popliteal fossa.
- *Diagnostics*: X-ray of the knee joint in two planes in standing including the patella (visualizing the joint space, the joint surfaces, and the axes).
- *DD*: Causes of secondary gonarthrosis.

20% of knee joint complaints are actually caused by a disorder of the hip joint.

Baker's Cyst (Popliteal Cyst)

Swelling of the posterior capsular membrane of the knee joint or of a communicating bursa (often the bursa of the medial gastrocnemius muscles, the semimembranosus muscle, or the popliteal muscle). The cyst is filled via a communication with the joint, but cannot drain itself.

- *Etiology*: Weakness of the posterior capsular membrane (often associated with degenerative changes at the posterior horn of the meniscus or in the cartilage) or via communication with the bursae.
- *History*: Nonspecific. Tenderness and a tautened feeling at the popliteal fossa.
- *Examination*: Firm and elastic swelling that is circumscribed, varies in size, and is clearly palpable in the popliteal fossa with the knee extended.
- *Diagnostics*: X-ray of the knee joint in two planes (to rule out gonarthrosis). Sonography (extent of the cyst, differential diagnosis). MRI (only in uncertain findings).
- *DD*: Ganglion cyst. Thrombosis. Thrombophlebitis. Tumors. Aneurysm. Lymph nodes.

- **Inflammatory disorders**

Nonspecific Inflammation

Bursitis

Common inflammation of the bursa in the knee joint. One differentiates purulent, hemorrhagic, serofibrinous, and serous inflammation. Calcification of the bursae can also occur (bursa calcarea). Acute and chronic bursitis. Mostly affects the suprapatellar bursa, the prepatellar bursa, the infrapatellar bursa, and the bursa anserina.

- *Etiology*: Infection. Chronic exposure to compression or pressure (tilers).
- *History*:
  Purulent bursitis: Severe pain, localized swelling and redness, and fever.
  Chronic sterile inflammation: Swelling and mild pain upon strain.
- *Examination*:
  Purulent bursitis: Severe localized swelling, redness, hyperthermia, severe tenderness to touch, and compression.
  Chronic sterile: Localized swelling and fluctuation. Slight to no tenderness.
- *Diagnostics*: X-ray of the knee in two planes and of the patella (to rule out pathological changes to the bone). Blood tests (erythrocyte sedimentation rate, CRP, leukocytes, elevated).

Bacterial gonitis (knee empyema)

Bacterial, nonspecific inflammation of the knee joint. Presents as either primary or secondary empyema.

- *Etiology*: Mostly staphylococcal, in some cases streptococcal, gonococcal.
  Primary gonitis: Direct contamination with pathogens in open wounds. Iatrogenic during knee surgery.

Secondary gonitis: Hematogenous deriving from another focus (tonsillar angina, dental root granuloma, furunculosis in children) or from a local focus (osteomyelitis, soft tissue infection).

- *History*: Initially severe knee pain, hyperthermia, swelling, fever, shivering, and impaired general condition.
- *Examination*: Patient is dehydrated, painful limping, redness, swelling, and hyperthermia. Circumference of the leg is increased at the knee joint, and effusion is present. Severe tenderness to touch, movement, and limitation of mobility.
- *Diagnostics*: X-ray of the knee joint in two planes and of the patella (to rule out pathological changes to the bone). Blood tests (erythrocyte sedimentation rate, CRP, elevated leukocytes). Joint puncture (swab, bacteriology).
- *DD*: Active gonarthrosis, reactive arthritis, and chronic polyarthritis. These conditions are, however, not associated with a severe reduction in the general condition.

■ Specific Inflammation

Tubercular gonitis

Specific inflammation of the knee by Mycobacterium tuberculosis. One distinguishes between primarily synovial and primarily osseous forms.

- *Etiology*: Inflammation mostly hematogenous from the primary infection site (*Mycobacterium tuberculosis*). Less commonly due to spreading of the osseous infection into the knee joint.
- *History*: Beginning symptoms are nonspecific. Diffuse pain, slowly increasing swelling, and muscular atrophy.
- *Examination*: Paleness (tumor albus). Fusiform swelling at the upper recessus (fungus) and doughy capsular swelling. Atrophy of the muscles of the upper leg compared to the opposite side.
- *Diagnostics*: X-ray of the knee in two planes and of the patella (to rule out pathological changes to the bone). Scintigraphy (increased accumulation). CT/MRI (extent of the process). Mantoux test or Tine test. Gastroscopy (acid-fast rods). Blood tests (erythrocyte sedimentation rate elevated).
- *DD*: Especially tumors.

■ Rheumatic Inflammation

Reactive arthritis

Nonspecific postinfectious arthritis of the knee. Can lead to gonarthrosis.

- *Etiology*: Presents following an enteric or urogenital infection. Commonly *Chlamydia*, *Borrelia*, *Neisseria*, *Yersinia*, and *Shigella*.
- *History*: Recurring swelling of the knee joint of varying degrees. Slight hyperthermia. Muscular atrophy. In the course of disease, secondary alterations leading to gonarthrosis.
- *Examination*: Slight capsular tension and hyperthermia. Increased circumference of the knee and effusion (◘ Fig. 3.17). In the course of disease, atrophy of the upper leg muscles compared to the opposite side and limitation of range of motion.
- *Diagnostics*: X-ray of the knee joint in two planes (to rule out pathological changes to the bone). Blood tests (erythrocyte sedimentation rate, CRP, leukocytes, arthritis serology: testing for antibodies, differential diagnosis).
- *DD*: Active primary or secondary arthrosis. Chronic polyarthritis. Psoriasis arthritis. Meniscal lesion. Chondromatosis. Tumors.

- **Traumatic disorders**

■ Fatigue Fracture

Incomplete fractures, mostly at the tibia, the fibula, or the distal femur. Fatigue fracture, though rare, is one of the causes for spontaneous limping in children.

- *Etiology*: Physical examination.
- *History*: More common in children. Slow progression leading to increasing pain in the knee joint, followed by sudden limping upon exerting stress to the knee joint.
- *Examination*: Painful limp. Localized tenderness.
- *Diagnostics*: X-ray of the knee and the lower leg in two planes (to visualize the fracture). Scintigraphy (increased accumulation at the fracture). MRI (extent of the fracture and its location).
- *DD*: Tumors.

■ Cruciate Ligament and Collateral Ligament Rupture

Rupture of the cruciate ligament and/or the collateral ligaments. Present in a context of capsular and

ligament injury of the knee. One distinguishes new and older ruptures and *complete and partial rupture. Also simple, complex* (*rotation*), *and combined instability*.

Simple instabilities are characterized by pathological mobility in one axis or plane. This includes anterior, posterior, lateral, and medial instability. In complex instabilities (*rotation instability*), *cruciate ligament injury is combined with injury to the collateral ligaments, the capsule, and the meniscus. This includes anteromedial instability, posterolateral rotation instability, and posteromedial instability. Combined instabilities are combinations of complex instabilities and can lead to complete knee dislocation*.

The most common is the anteromedial rotation instability ("*unhappy triad*"). *This is defined as a combined rupture of the anterior cruciate ligament, the medial collateral ligament, and the internal meniscus*.

- *Etiology*: Mostly new valgus flexion–external rotation trauma (e. g., soccer or other ball sports, skiing often leads to anteromedial instability). Also seen when falling from a standing position (e. g., after downhill skiing).
- *History*: Precise patient history including the date of the accident, the place, and the mechanism of injury. Furthermore difficulty walking or practicing sports after the accident as well as joint swelling.
  New rupture: Snapping noise during trauma, followed by acute pain. The knee swells within 6 h (blood), mobility is impaired by pain.
  Older rupture: Sensation of knee "giving way". Instability upon ascending stairs, when walking or on uneven surfaces or when suddenly changing direction. Also following a sudden twist. In some cases recurring swelling. Some patients describe a snapping of the tibial head when walking. No limitation of range of motion. Atrophy of the upper leg muscles is possible.
- *Examination*: Capsule swelling, effusion (Fig. 3.17), and positive meniscus symptoms.
  New rupture: Mobility limited by pain.
  Older rupture: Decrease of the upper leg circumference. Mostly normal range of motion.

Examination following new trauma is difficult as the tests are often not clearly positive!

- *Drawer*: Anterior and posterior translation of the "drawer" phenomenon positive normal 0–5 mm (Fig. 3.29). Anterior translation and posterior passive translation of the knee are possible (tested in 90° flexion). The examiner will find no clear end resistance in the direction of the injured ligament. *Rotatory drawer* is positive (internal rotation is used to test the lateral ligaments, external rotation to test the medial ligaments). In some cases posterior translation of the drawer phenomenon is positive. Instability is recorded as follows: 3–5 mm +, 5–10 mm ++, >10 mm +++. Anteromedial instability grade I, II, and III.
- *Sideward Instability*: Normal sideward opening of the knee in 30° flexion: 5–12 mm medial (less in women than in men), lateral 10–15 mm. Medial or lateral sideward instability will increase (test in full extension and in 30° flexion) (Fig. 3.28).
- *Lachman's test* positive (Fig. 3.30), often the only test tolerated by the patient in new injuries. *Pivot-shift test* positive (Fig. 3.31, inaccurate in new injuries). *Overextension test* positive. (*Lesion of the anterior cruciate ligament and of the dorsomedial/dorsolateral capsule*—extension clearly increased in comparison to the opposite side, tested in the supine position with elevated legs.)

The stability of the ligaments in the injured knee needs to be compared to the opposite side in order to determine the individual extent of the instability.

- *Diagnostics*: X-ray of the knee joint in two planes (to rule out injury to the bone). MRI (if unclear or older fractures). Puncture in new injury (blood indicates cruciate ligament tear).

▪ *Quadriceps Muscle Rupture*

Rupture of the tendon of the quadriceps muscle proximal to the patella. Easily overlooked.

- *Etiology*: Mostly degenerative changes to the tendon. Often caused by stumble or a fall with little injury elsewhere.
- *History*: Middle-aged patients and older patients. Severe pain, difficulty walking backward, and hematoma.
- *Examination*: Swelling in the knee joint, effusion (Fig. 3.17), and localized tenderness. In active extension (lifting the leg) palpable gap above the patella.

- *Diagnostics*: X-ray of the knee in two planes (to rule out changes to the bone). Sonography (to visualize the gap proximal to the patella, effusion).
- *DD*: Tumors. Patella tendon rupture and avulsion fracture of the inferior patella pole (in sideway X-ray: patella alta).

Patella Fracture

Fracture of the patella. Around 1% of all fractures. Horizontal, longitudinal, diagonal, stellate, and comminuted. Osseous avulsion from the patellar pole. Dislocated and non-dislocated fractures.

- *Etiology*: Mostly direct trauma (blow to the knee from the front or dashboard injury). Less common are indirect injuries via sudden impairment of knee extension.
- *History*: Mostly younger patients. Severe pain (bent knee is held by both arms). Severe swelling (hemarthrosis). Mobility in the knee is limited by pain.
- *Examination*: Severe swelling with tight skin, localized hematoma, and tenderness.
  Dislocated fractures: Palpable gap over the patella. The leg cannot be extended or lifted.
  Non-dislocated fracture: The leg can be lifted in the extended position.
- *Diagnostics*: X-ray of the knee joint in two planes (to visualize the fracture). In unclear findings, additional X-ray of the surrounding structures of the patella should be performed.

Proximal Tibial Fracture and Tibial Shaft Fracture

Tibial head fracture

Fracture of the proximal tibia. Mono- or bicondylar intra-articular fracture. Often combined with overextension or rupture of the opposite capsule–ligament apparatus. Classification according to Schatzker in six types. Slight valgus position mostly causes lateral compression fracture.

- *Etiology*: Mostly occurs due to falling onto the extended knee.
- *History*: Swelling in the knee joint (hemarthrosis). Extensive hematoma is possible. Dislocation fractures are mostly associated with severe tissue injury to the joint capsule and the ligaments as well as neurovascular injury.
- *Examination*: Difficult in the acute stage. Hematoma, capsular swelling, dancing, and patella. Eventually superficial skin abrasion. Localized tenderness. Often increased sideway instability (due to injury of the opposite collateral ligament, to be examined under anesthesia).
- *Diagnostics*: X-ray of the knee joint and the proximal lower leg in two planes (to visualize the fracture).

Tibial shaft fracture

Fracture of the tibial shaft. In adults, apart from ankle and femoral shaft fracture, it is the most common fracture in the lower extremity. Seen as an isolated injury or in a context of polytrauma. One distinguishes spiral, horizontal, and diagonal (most common) fractures. With or without a wedge. In childhood, fracture presents as a greenstick fracture. The fractures are dislocated or not dislocated and present as open or closed injuries.

The open tibial shaft fracture is a surgical emergency.

- *Etiology*: Indirect (torsion forces, e.g., skiing and then combination with fibular fracture) and direct blow (mostly in sport, often with associated fibular fracture).
- *History*: Acute pain. The leg does not tolerate strain.
- *Examination*: Abrasion or extensive injury to the skin. Swelling and hematoma in the area of the fracture. Axis deviation is possible. Localized tenderness to touch and compression, pain when testing the function of the neighboring joints.

In fractures of the long bones, the joints must be examined above and below the fracture. A distal tibial shaft fracture can be combined with a proximal fibular fracture.

- *Diagnostics*: X-ray of the lower leg with the knee joint and the ankle in two planes (to visualize the fracture).

Distal Femur Fracture

Supracondylar and intercondylar femoral fracture in middle-aged patients and in older patients. Fracture of the femur, in some cases with intra-articular involvement. Common in the osteoporotic bones of older persons also leading to difficulties in treatment.

- *Etiology*: Fall onto the knee. Often seen in osteoporotic bone.
- *History*: Severe acute pain in the knee. Swelling of the knee joint (hemarthrosis). Movement in the knee joint is limited due to pain.

- *Examination*: Firm swelling in the knee joint. Hematoma. Severe tenderness to touch and pressure.
- *Diagnostics*: X-ray of the knee joint in the upper and lower leg in two planes (to visualize the fracture).

Intercondylar and condylar femoral fracture in young adults

Distal femur fracture, often with intra-articular involvement. Common in combination with an osteochondral fracture and *meniscal or capsule injuries. Often associated with hip and patellar fractures.*

- *Etiology*: In general, direct blow.
- *History*: Severe acute pain. Swelling of the knee (hemarthrosis). Eventually neurological deficits. Mobility in the knee is limited.
- *Examination*: Firm knee joint swelling. Examination of the neurovascular structures: Be careful! A non-palpable pulse of either the popliteal, posterior tibial, or dorsalis pedis artery is a surgical emergency!
- *Diagnostics*: X-ray of the knee joint with the upper and lower leg in two planes (to visualize the fracture).
- *DD*: Pay attention to the possibility of further associated fractures of the hip.

■ Epiphysis Fracture of the Distal Femoral Epiphysis

Fracture that is common in adolescents.

- *Etiology*: Powerful abduction of the extended knee can lead to lateral avulsion of the distal femoral epiphysis. Hyperextension (anterior avulsion).
- *History*: Young patients. Severe acute pain and swelling of the knee (hemarthrosis). Neurovascular losses (impingement of the popliteal artery by the fracture). Knee movement is not possible due to pain.
- *Examination*: Firm knee joint effusion. Examination of the neurovascular structures. Be careful! A non-palpable pulse of either the popliteal, the posterior tibial, or the dorsalis pedis artery is a surgical emergency!
- *Diagnostics*: X-ray of the knee with the upper and lower leg in two planes (to visualize the fracture).
- *DD*: Pay attention to associated fractures.

- **Tumor disorders**

■ Primary Tumors

Solitary juvenile bone cyst

Probably the most common tumor disorder. Mostly presents in the proximal humerus and the proximal femur. Also seen in the distal tibia and the calcaneus. Recurrence is possible.

- *Etiology*: Tumorlike disorder of unknown original tissue.
- *History*: Can present in very young children, mostly between the ages of 8 and 15. No clinical symptoms, in some cases spontaneous fracture.
- *Examination*: Signs of fracture.
- *Diagnostics*: X-ray of the knee with the neighboring upper and lower leg in two planes (to visualize the tumor: smooth, oval-shaped defect). Scintigraphy (increased accumulation). Curettage or other forms of biopsy.
- *DD*: Aneurysmal bone cyst.

Aneurysmal bone cyst

1–2% of all primary bone tumors. Mostly in the proximal or distal femur, at the tibia, as well as in the spine or pelvis. Recurrence rate of 20%.

- *Etiology*: Benign tumor.
- *History*: Mostly presents in patients younger than 20. Barely any clinical symptoms, spontaneous fracture can occur.
- *Examination*: Nonspecific, eventually pain and swelling.
- *Diagnostics*: X-ray of the knee joint with the upper and lower leg (to visualize the tumor: similar to the juvenile bone cyst, but the bones are further apart.) Scintigraphy (increased accumulation). Curettage or other forms of biopsy.
- *DD*: Solitary juvenile bone cyst. Giant cell tumor. Fibrous dysplasia.

Hereditary multiple exostoses

Exostoses, mostly arising from the epiphysis cartilage of the long bones. Mostly seen in the humerus, the tibia, the radius, and the ulna.

- *Etiology*: Dominantly inherited systemic disorder. More common in men. Penetrance is lower in the female sex.
- *History*: Often presents in infants. Manifests during growth years. Pain in some cases, more

often compression of neighboring arteries and nerves. Impaired joint function.
- *Examination*: Mostly palpable, deeply located tumor. Slight tenderness. Sensory function loss in the areas supplied by the neighboring nerves. The mobility in the knee joint is barely limited. At the hand, one often finds a shortening of the ulna and the resulting manum valgum. At the hips, one often finds a limitation of external rotation, reduction in the size of steps when walking, and rotation of the pelvis when the leg of the same side is translated forward.
- *Diagnostics*: X-ray of the region suffering tenderness (to visualize exostosis).

Synovial chondromatosis

Multiple, partly osseous neoplasia in the joint that can enter the synovial membrane or occur as a free particle in the joint. Mostly affects the knee and the elbow, but also other joints.
- *Etiology*: Benign neoplasia of the synovial membrane. Metaplasia in the joint capsule involving cartilage tissue. The direct cause is unknown. Exogenous and endogenous factors are being discussed. Increased incidence following recurring trauma at the elbow has been described.
- *History*: More common in men. Sharp pain when walking and placing joint under strain and impingement signs. Left untreated, the disorder can lead to secondary gonarthrosis.
- *Examination*: Capsular swelling, effusion (Fig. 3.17), and in some cases palpable free-moving body in the joint. Flexion and extension deficit including axis deviation only sets in later.
- *Diagnostics*: X-ray of the knee in two planes and of the patella (visualizing the joint space, joint surface, and free bodies in the joints space, differential diagnosis). Arthroscopic biopsy.
- *DD*: Active gonarthrosis. Reactive arthritis. Villonodular synovitis. Psoriatic arthritis.

Villonodular synovitis

Benign, tumorlike growth in the synovial membrane. One distinguishes a nodular and a pigmented form. Due to its locally destructive character, the pigmented form can lead to bone and subsequently joint destruction.
- *Etiology*: Unknown. Also considered a semi-malignant tumor.
- *History*: The nodular form presents acutely, and the diffuse form mostly presents only in one joint. Joint swelling (recurring bloody effusions), impingement, in the course of disease atrophy of the upper leg muscles, malpositioning, and impairment of mobility.
- *Examination*: Circumference of the knee joint is increased and effusion (Fig. 3.17). In the course of disease, atrophy of the upper leg muscles. Limitation of mobility (extension deficit, flexion inhibition).
- *Diagnostics*: X-ray of the knee joint in two planes and of the patella (to rule out pathological changes to the bone, differential diagnosis). Arthroscopic biopsy.
- *DD*: Reactive arthritis. Active gonarthrosis. Chondromatosis. Psoriasis arthritis.

Giant cell tumor

Relatively common tumor, located in the epiphysis (only the chondroblastoma is more common). Has a tendency to recur following resection. In 10 % of cases, there is real metastasis with a destructive character. Develops slowly. Classification according to Enneking in stage I to III.
- *Etiology*: Due to the malignant character and the possibility of metastasis, this tumor is considered semi-malignant.
- *History*: Only presents after completion of growth. Mostly between the ages of 30 and 40. Patients may present with knee pain, swelling, and in some cases spontaneous fracturing.
- *Examination*: Possible swelling, effusion (Fig. 3.17), and in some cases fracture.
- *Diagnostics*: X-ray of the knee joint with the upper and lower leg in two planes. CT/MRI (to rule out pathological changes to bone, differential diagnosis). Scintigraphy (increased accumulation). Histology.
- *DD*: Osteosarcoma. Chondroblastoma. Aneurysmal bone cyst. Metastasis.

Osteosarcoma

With 40 %, it forms the most common malignant bone tumors. Mostly affects the growth-intensive metaphyses around the knee. Another common location is the proximal humerus. The tumor grows quickly and shows hematogenous metastasis.

- *Etiology*: Malignant tumor of bony origin.
- *History*: Predominantly affects adolescents, especially during puberty. During the first 6–8 weeks of disease, patients present with nonspecific pain, e. g., in the knee. These are often associated with excessive strain or trauma. In some cases, spontaneous fracture is conspicuous.
- *Examination*: Palpable swelling at the upper leg, localized tenderness, and fracture signs.

In unclear knee pain, possible injury in the hip and the femur shaft must always be taken into account as well!

- *Diagnostics*: X-ray of the upper leg with the hips and the knee in two planes (pathological changes to bone), scintigraphy (increased accumulation), CT/MRI, and angiography (extent of the process and the proximity of key vessels or nerves). Biopsy.
- *DD*: Ewing sarcoma. Giant cell tumor. Aneurysmal bone cyst. Fibrous dysplasia.

Ewing sarcoma

The third most common malignant tumor. Mostly affects the diaphysis and in some cases the metaphysis of the femur, the tibia, or the pelvis. Early metastasis into the lung and other organs.

- *Etiology*: Highly malignant tumor originating from mesenchymal cells.
- *History*: Predominantly seen in children up to the age of 15. Localized, alternating, and tightening pain and swelling over the course of months. Fatigue, reduced general condition, and fever.
- *Examination*: Palpable swelling at the upper leg. Localized redness and hyperthermia and localized tenderness.
- *Diagnostics*: X-ray of the upper leg with the hips and the knees in two planes (pathological changes to the bone). Sonography (extent of the swelling). Blood tests (inflammation). Scintigraphy (increased accumulation). CT/MRI (extent of the growth). Biopsy.
- *DD*: Osteosarcoma. Neuroblastoma. Eosinophilic granuloma. Acute leukemia.

The most important differential diagnosis of Ewing sarcoma is hematogenous osteomyelitis.

- *Neurological disorders*

Peroneal nerve paresis (*L4-S2*)

Injury to the peroneal nerve, mostly at the fibular head. 10 % of nontraumatic nerve lesions.

- *Etiology*: Mostly compression injury. Predominantly iatrogenic in the form of positioning (anesthesia in surgery, casts, tight plasters, trauma).
- *History*: Gait insecurity. Feet cannot be elevated. Sensory function loss at the foot.
- *Examination*: Steppage gait. Foot dorsiflexor and toe dorsiflexor weakness (4-0) (Fig. 1.47). Hypesthesia between the first and the second toe, at the back of the foot, and at the lateral distal part of the lower leg. Achilles tendon reflex can be elicited.
- *Diagnostics*: If the disorder does not improve, neurological consultation (electromyography, electroneurography, new or old damage, denervation, repair).
- *DD*: Root lesion L5 (posterior tibialis weakened or absent).

■ Saphenous Nerve Compression Syndrome

Injury to the saphenous nerve, mostly in the adductor channel (*Hunter channel*). *Also presents as isolated injury of the infrapatellar ramus* (*gonalgia paresthetica*).

- *Etiology*: Iatrogenic in varicose vein operations. Stenosis of the adductor channel. Injury at the entry site through the fascia cruris.
- *History*: Pain and sensory function loss distal to the injury at the lower leg or knee.
- *Examination*: Hypesthesia at the medial lower leg or medially below the knee.

3.4 Ankle and Foot

3.4.1 Systematic Examination

- **Local findings**

Gait	Inconspicuous/right/left limping	Painful limping, shortening limping, guarding limping, stiffened limping
Axes/position	Physiological/pathological (right/left):	Heel/ dorsal foot/hindfoot/midfoot/forefoot (pes valgus/pes varus; pes equinus; pes adductus/pes supinatus)
	Transverse and longitudinal arches (pes excavatus/pes planus)	Actively/passively correctable/not correctable
	Big toe: bunion (varus/flexus)	--Degrees
	Toes 2-3-4-5 (claw toe/hammer toe)	Contracture/no contracture
Metric deviations	None; if present (right/left)	Localization; plus variation/minus variation Gigantism/dwarfism Amputation
Swelling/redness/ hyperthermia	None; if present (right/left)	Localization/extent/circumference/ consistency (soft/firm/movable)
Joint swelling	None; if present: light/severe; painless/painful	Localization
Hematoma/abrasion/open wounds	None; if present:	Localization/extent/circumference
Scars	None; if present:	Localization/extent/consistency (soft/firm/ movable)
Nails of the foot	Inconspicuous/pathological: onychomycosis (right/left)	Toes 1–2–3–4–5
Skin	Inconspicuous; dry/moist; rhagades/ulcer/callus/clavi, nodules (right/left):	Toes 1–2–3–4–5, plantar/dorsal, heel/ midfoot/tarsometatarsal joint/proximal interphalangeal and distal interphalangeal joints
Muscles	Calf/anterior tibial muscle/ peroneal muscle	Highly developed/wasted/shortened Atrophy (significant?), muscle tone increase or decrease (right/left)
Circumference	Lower leg smallest circumference Forefoot ball	--cm (right/left)
Mobility of the ankle	Dorsiflexion/plantar flexion Eversion/inversion	--/--/- -Degrees (passive, right/left)
Mobility big toe	Dorsiflexion/plantar flexion (proximal joint, distal joint)	--/--/- -Degrees (passive, right/left)
Mobility toe 2–5	Dorsiflexion/plantar flexion (metatarsal joint, proximal interphalangeal joint, distal interphalangeal joint)	Free/impaired (passive; right/left)

Crepitation	None; if yes: fine/course (right/left)	Ankle, tarsometatarsal joint of the big toe
Pain lower leg	None; if present (right/left):	Pain (and instability) at the syndesmosis Tenderness to pressure at the tibia or, in the course of disease, at the fibula
Ankle pain	None; if present: positive (right/left)	Mobility pain (direction/persistent/at maximal ROM)/tenderness to pressure: joint space (anterior–posterior, medial/lateral), medial, and lateral malleolus
Pain at the hindfoot/midfoot/forefoot	None; if present: positive (right/left)	Movement-induced pain/tenderness to pressure: Achilles tendon/heel, midfoot/toe joints (plantar/dorsal) tenderness at the base of the fifth metatarsal
Ligaments of the ankle	Stable/increased/laxity/anterior translation of the drawer sign possible (right/left; medial/lateral)	In a neutral position
Achilles tendon	Intact/palpable gap Thompson test	Negative/positive Right/left

- **Neurology**

Deep tendon	Quadriceps tendon reflex (L4) Posterior tibial reflex (L5) Achilles tendon (S1)	Right/left Vigorous/decreased/absent/supernormal (hyperreflexic)/cloni (right/left)
Sensory function examination	Dermatome (segment assignable/not exactly assignable)	Hypesthesia/paresthesia Dysesthesia (right/left)
Motor function	Standing on the heels (foot and big toe dorsiflexors; L5, sciatic nerve, peroneal nerve). Standing on the toes (foot plantar flexors; S1)	Right/left intact/impaired function (M0–M1–M2–M3–M4–M5)

- **Perfusion**

Arteries	Dorsalis pedis artery Posterior tibial artery	Fully/barely/not palpable (right/left)
Veins	Varicosis cruris Venous stasis Hyperpigmentation	None/present(right/left)
Capillary pulse	Tips of the toes	Visible/invisible

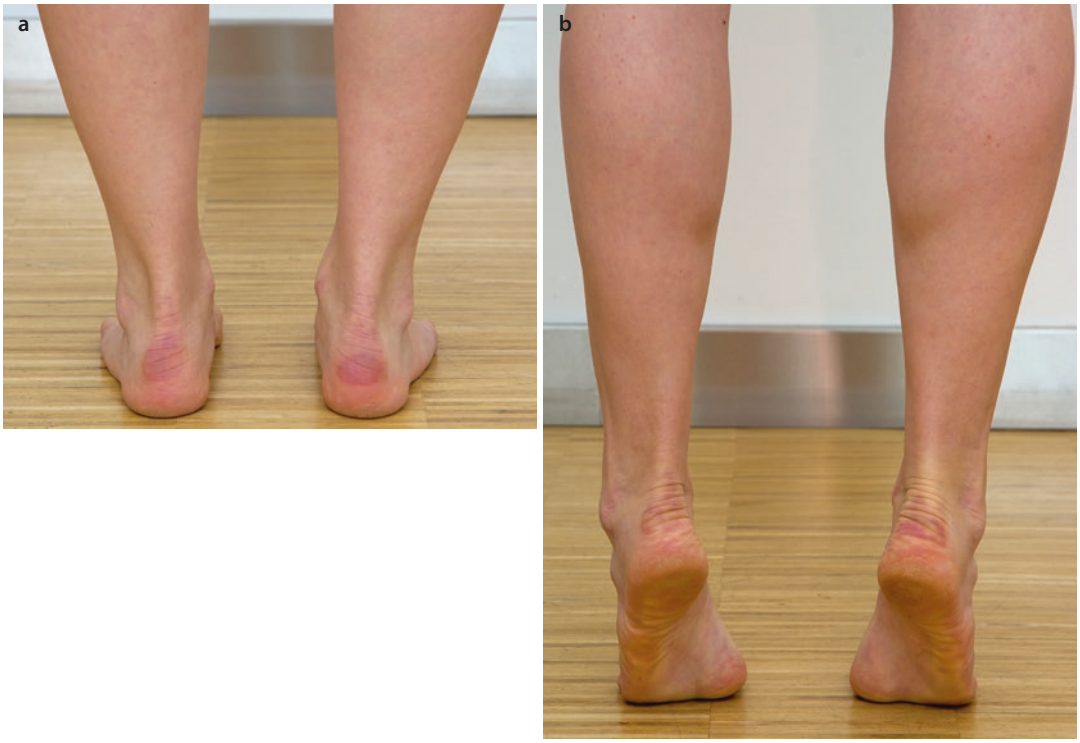


Fig. 3.32 (**a**, **b**) Testing the heel position when standing (**a**). Initially the valgus position is inspected from the back. Simultaneously the configuration of the longitudinal arch is inspected. The patient stands on the tips of his toes (**b**). This makes visible to what extent the longitudinal and transverse arch lift. Decreased lifting of the arches indicates an insufficiency in the arches

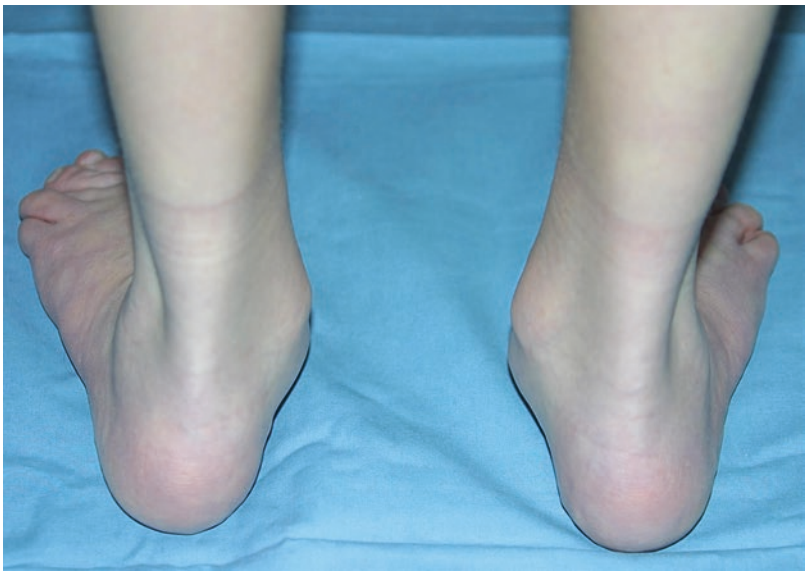


Fig. 3.33 Pes planovalgus

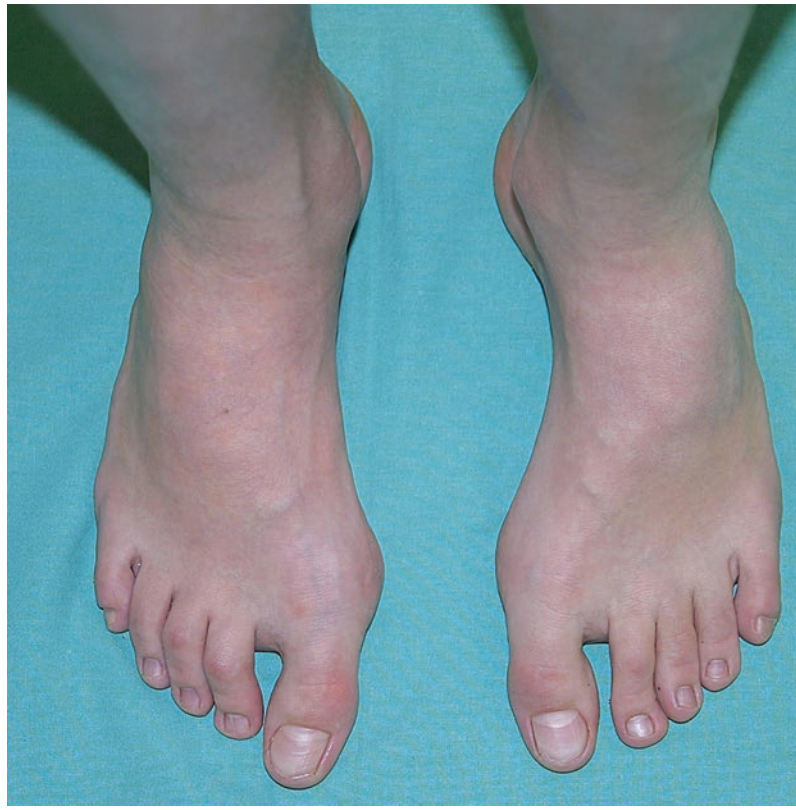


Fig. 3.34 Pes adductus with a hammer toe (second toe bilateral)

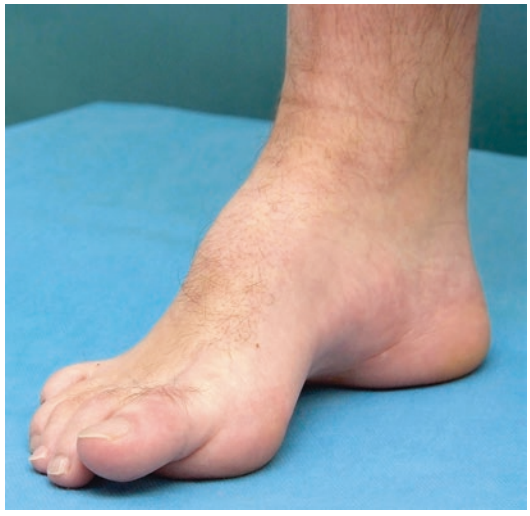


Fig. 3.35 Pes excavatus

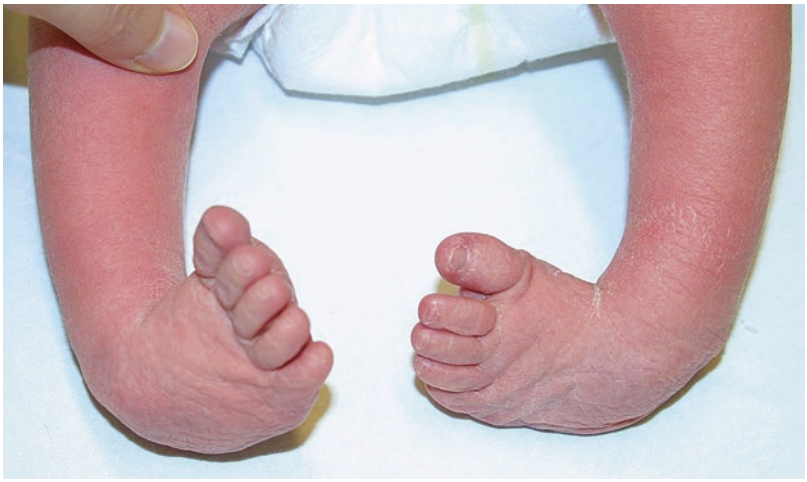


Fig. 3.36 Congenital clubfoot

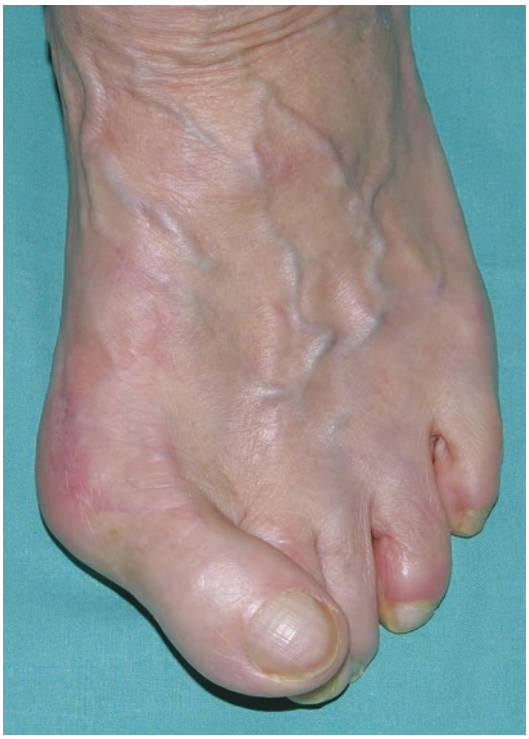


Fig. 3.37 Bunion with medial pseudoexostosis

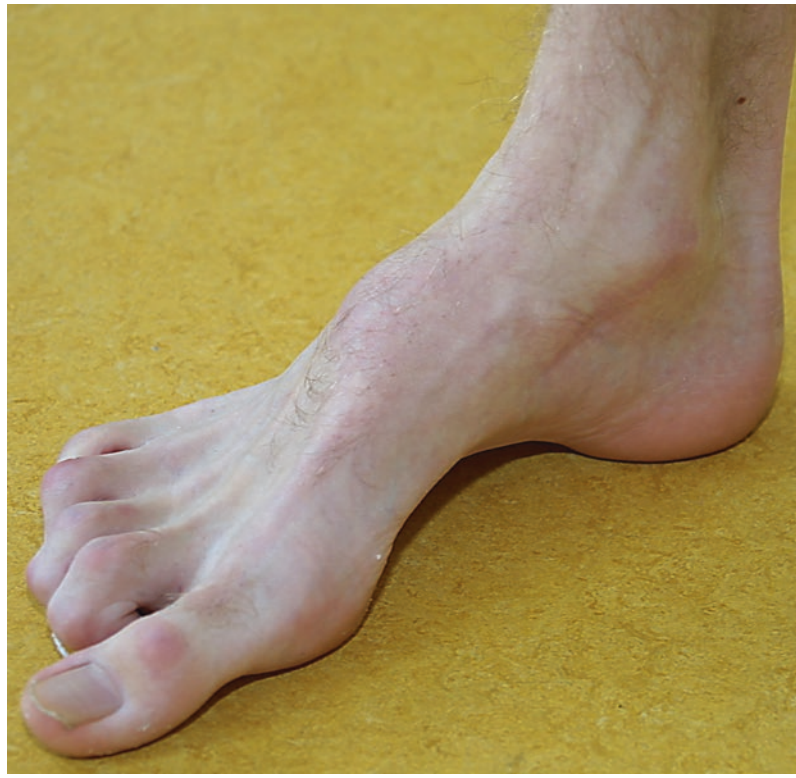


Fig. 3.38 Claw toes (second to fourth toe)

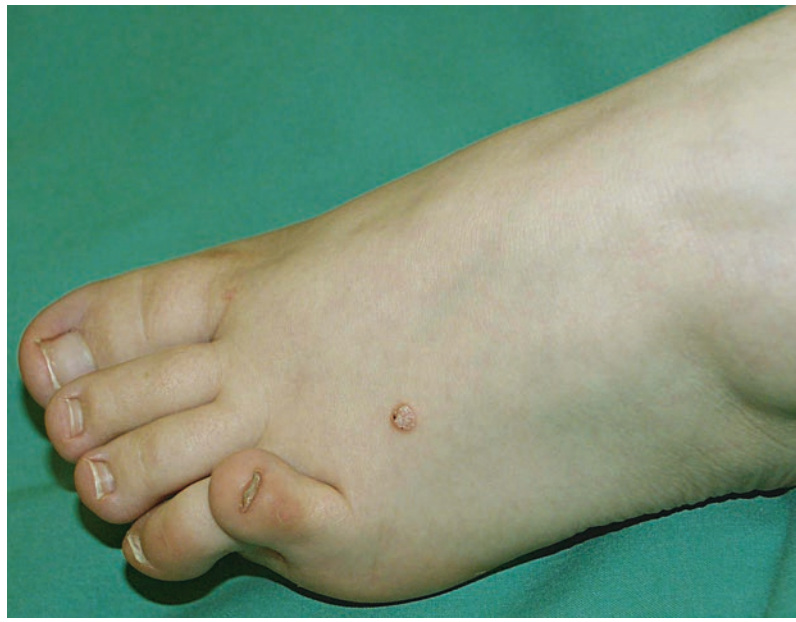


Fig. 3.39 Digitus quintus superductus

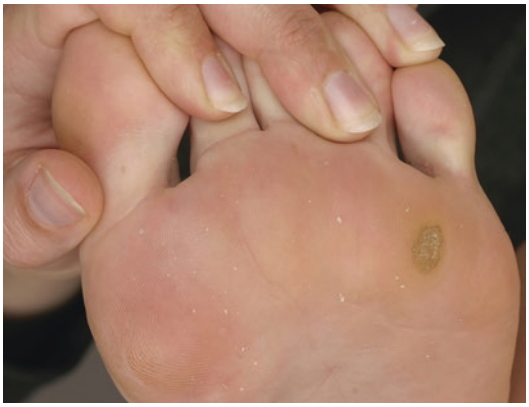


Fig. 3.40 Clavus

Fig. 3.41 (**a**, **b**, **c**) Testing dorsiflexion (**a**) and plantar flexion (**b**). Normal ROM for dorsiflexion/plantar flexion 30/0/50°. If preexisting drop foot deformity is present, then, by bending the knee to 90° and testing dorsiflexion, one can distinguish a shortening of the gastrocnemius muscle from a shortening of the soleus muscle. If only the gastrocnemius muscle is shortened, dorsiflexion of the ankle is possible with flexed knee, because the muscle is relaxed (**c**)

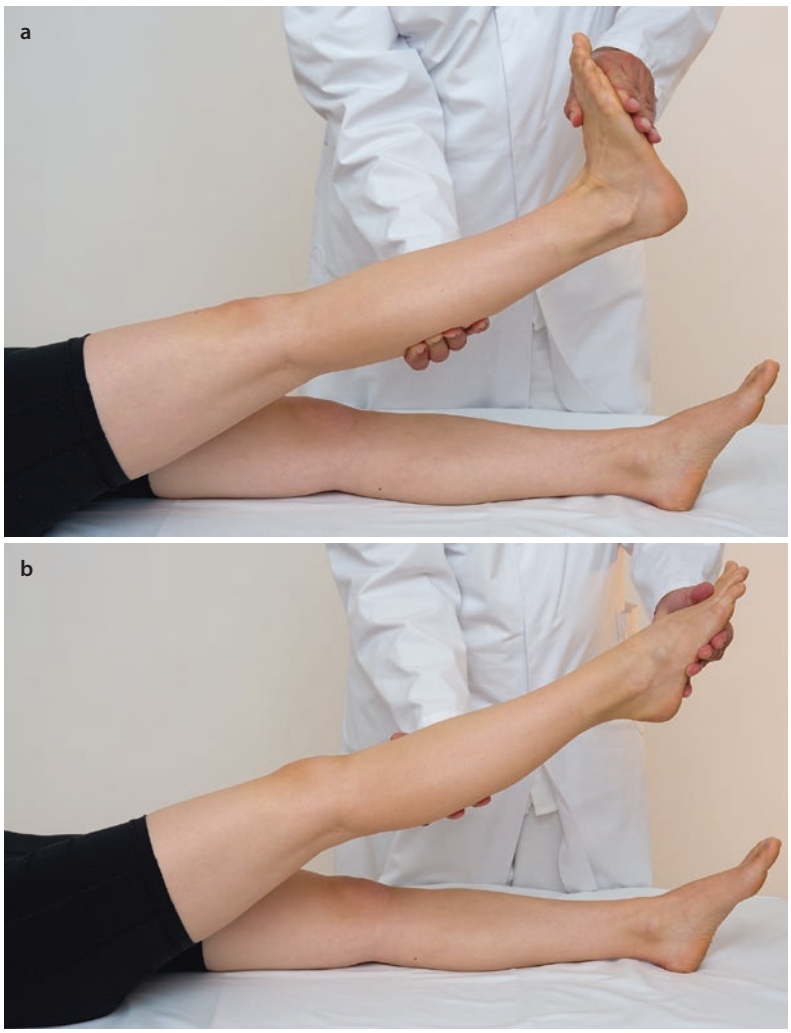


Fig. 3.41 (contiuned)

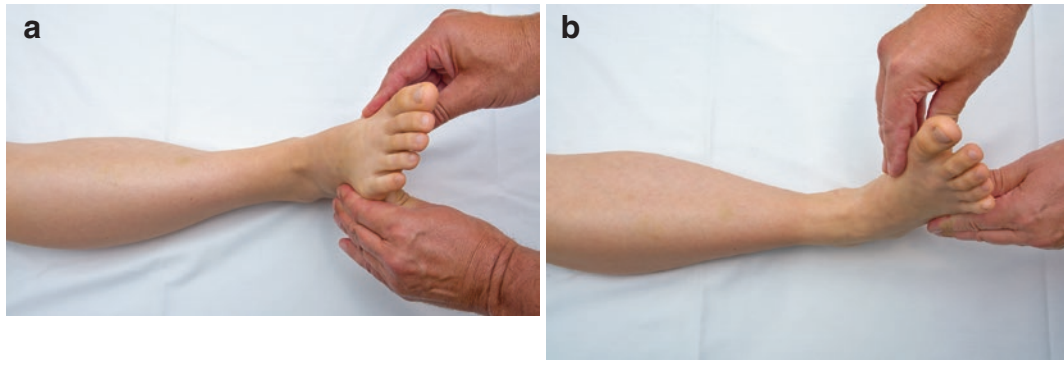


Fig. 3.42 (**a**, **b**) Testing eversion (**a**) and inversion (**b**) in the ankle. The normal ROM for eversion/inversion is 15/0/50°

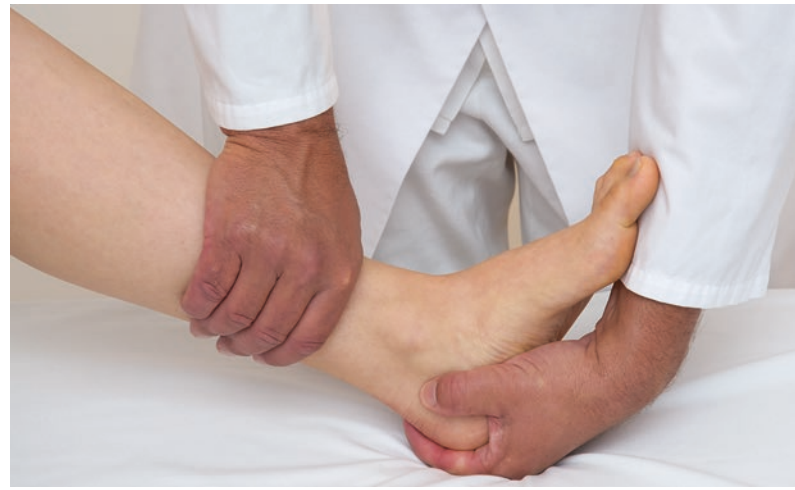


Fig. 3.43 Testing the drawer sign in the ankle; anterior translation. The examiner holds the heel from the sole of the foot with one hand; the opposite side is fixed from the anterior to the distal tibia. The test is positive if anterior translation is possible

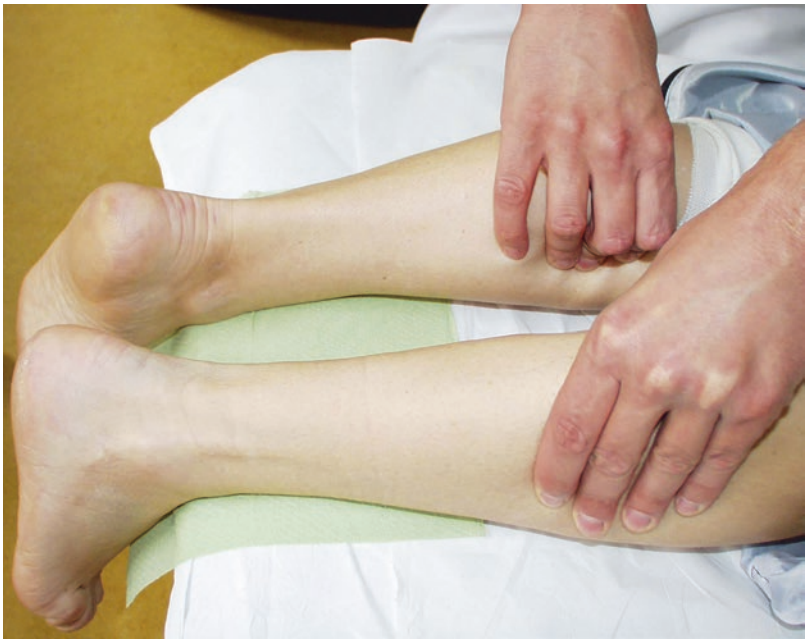


Fig. 3.44 Thompson test: the patient lies on his/her stomach. The feet hang freely and the examiner compresses the calves. When the calf is compressed, a physiological plantar flexion of the foot should present. The sign is positive if the foot cannot be plantar flexed. This is a strong indication for an Achilles tendon rupture

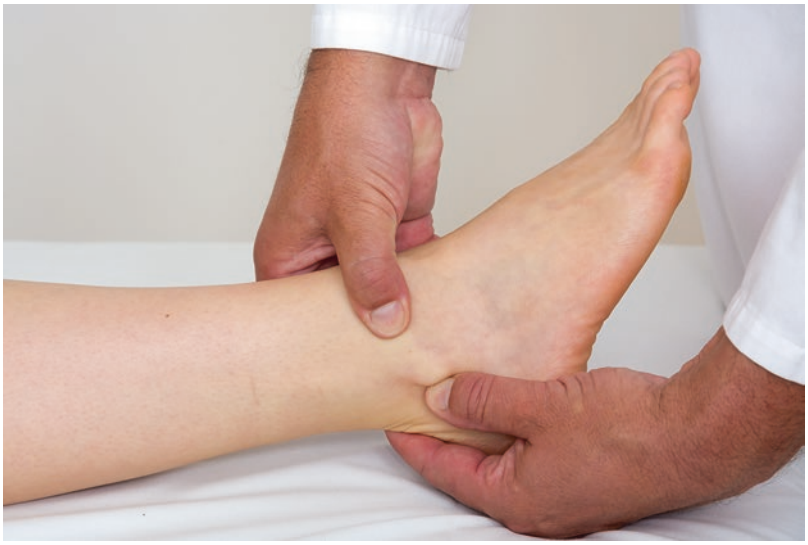


Fig. 3.45 To test syndesmosis stability, the lateral malleolus is anteriorly and dorsally fixed, and translation in an anterior–posterior direction is performed. An increased instability is a sign for injury to the syndesmosis. The opposite side should be used as comparison. The damage to the syndesmosis can be tested by revealing tenderness anterior and dorsal to the lateral malleolus

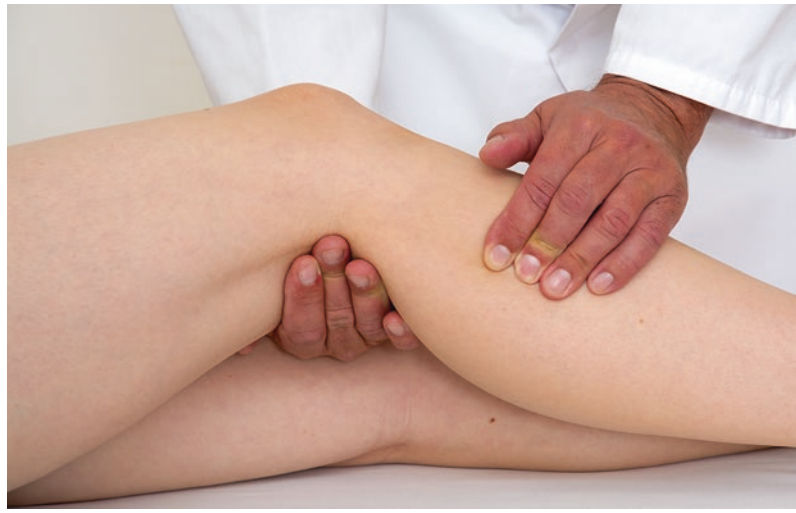


Fig. 3.46 If a syndesmosis rupture is suspected, it is essential to rule out a high fibula fracture. The fibula must be palpated. If tenderness is reported, X-ray imaging of the whole fibula should be performed

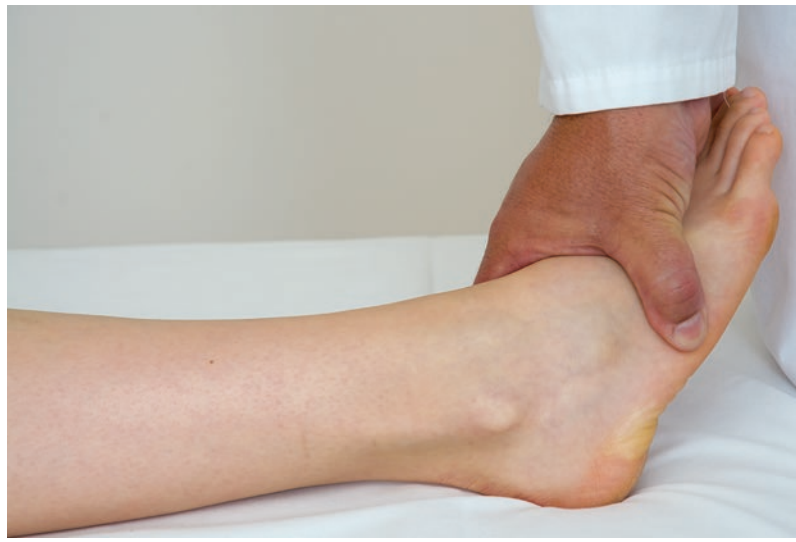


Fig. 3.47 In case of a distortion trauma of the ankle, the sudden traction in the peroneal tendon at its insertion site may lead to a fracture at the base of the fifth metatarsal bone. When examining ankle distortion, one should always rule out a fifth metatarsal bone fracture. In case of fracture, tenderness to pressure over the base of the metatarsal bone may be present

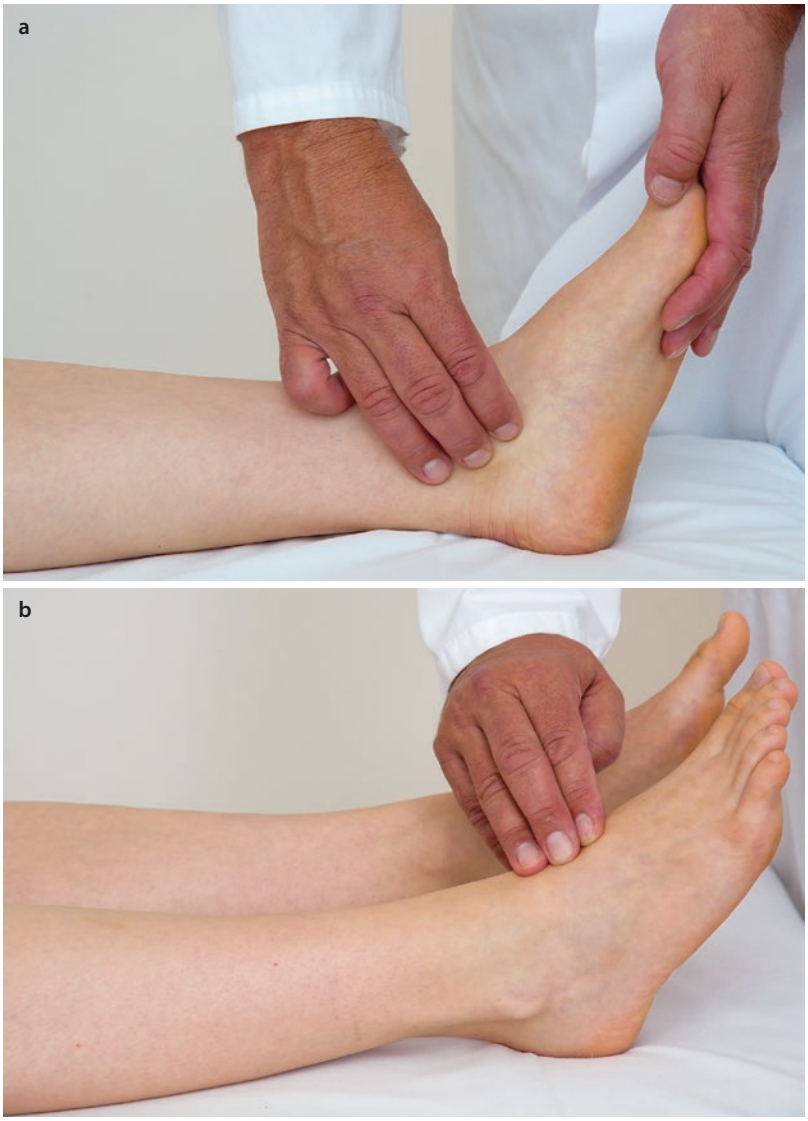


Fig. 3.48 (**a**, **b**) Testing the pulse of the posterior tibial artery (**a**) and the dorsalis pedis artery (**b**)

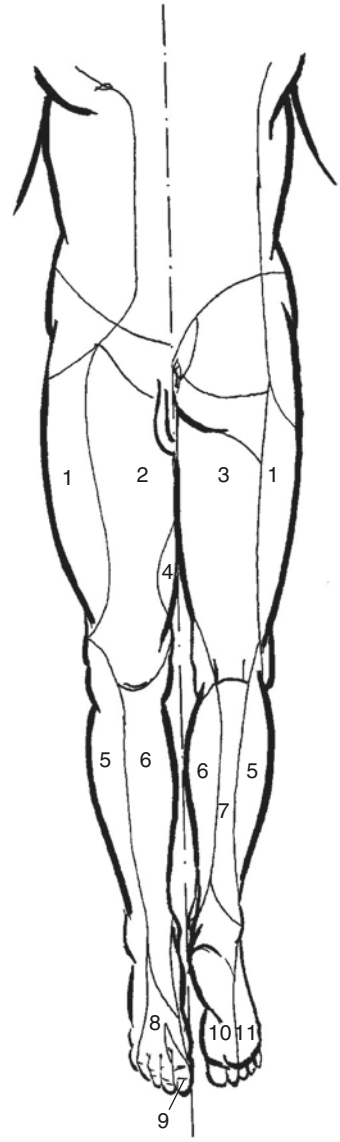


Fig. 3.49 Peripheral sensory innervation in the trunk and the lower extremity. 1 N. cutaneus femoris lateralis; 2 N. Femoralis; 3 N. cutaneus femoris posterior; 4 N. obturatorius (Ramus cutaneus); 5 N. cutaneus surae lateralis; 6 N. saphenous; 7 N. suralis; 8 N. peroneus superficialis; 9 N. peroneus profundus; 10 N. plantaris medialis; 11 N. plantaris lateralis

3.4.2 Leading Symptoms at the Ankle and the Foot

The leading symptoms in the ankle and the foot are summarized in Table 3.3.

Table 3.3 Leading symptoms in the ankle and the foot

History	Pain	Local findings, functional testing	Sensory function disorder	Motor function disorder	Points to
Tight shoes at the heels	Pain at the heel when walking	Prominence of the heel at the insertion site of the Achilles tendon, local redness, local tenderness	None	None	*Haglund's deformity*
Mostly older patients, occupation involving standing	Strain-dependent sharp pain under the heel	Localized tenderness under the heel	None	None	*Calcaneal spur*
Mostly boys around the age of 6, limited rolling of the foot over the external margin of the foot	Strain-dependent pain at the tarsal bones	Localized swelling and tenderness over the navicular bone	None	None	*Köhler's disease*
Mostly men, swelling at the base joint of the big toe, rolling of the foot over the external margin	Strain-dependent pain in the metatarsophalangeal joint of the big toe	Base joint of the big toe swollen, localized tenderness to pressure and movement, dorsiflexion painfully limited	None	None	*Hallux rigidus*
Following a large meal or alcohol consumption, acute redness and swelling at the base joint of the big toe	Acute stinging pain at the big toe tarsometatarsal joint	Local redness and swelling of the big toe tarsometatarsal joint, severe local pain elicited by touch, tenderness	None	None	*Gout*
History of rheumatoid arthritis, increasing foot deformity	Especially strain-dependent pain	Severe flatfoot, bunion, callus, hammer toe, claw toe	None	None	*Rheumatic foot*

(continued)

Table 3.2 (continued)

History	Pain	Local findings, functional testing	Sensory function disorder	Motor function disorder	Points to
History of diabetes, increasing foot deformity	Restless sensation in the feet, burning sensation especially at night	Diffuse or circumscribed swelling, coarsening of the foot (flatfoot), eventually ulceration, pulse often not palpable, quadriceps and Achilles tendon reflexes decreased	Socklike extent (distally symmetrical)	None	*Diabetic foot*
When performing sports, a sudden kick in the heel is felt; normal walking is not possible	Acute pain above the heel	Limping gait, palpable gap in the middle of the Achilles tendon, positive Thompson test	None	None	*Achilles tendon rupture*
Supination trauma (soccer, volleyball), swelling below the medial malleolus	Ankle pain at rest, aggravated by strain	Local swelling and hematoma, localized tenderness, pain aggravation during forced passive inversion of the foot, eventually positive anterior translation in the drawer sign	None	None	*External ligament rupture*
Longer marching	Delayed strain-dependent pain at the forefoot	Localized swelling and tenderness over the second and third metatarsal bone	None	None	*Marching fracture*
Bunion and pes transversoplanus (transverse arch collapse)	Burning, "electric" pain at the forefoot especially following longer walking	Severe intermetatarsal tenderness to pressure, local anesthetic injection offers immediate pain relief for 1–3 h	Paresthesia at the forefoot	None	*Morton's neuroma*

3.4.3 Disorders of the Ankle and the Foot

- **Clinical disorders**

■ *Callus and Corns*

Callus is a thickening and coarsening of the outermost layer of the skin. Corns (clavus) involves callus that reaches into the subcutaneous layer of the skin.

- *Etiology*: Unphysiological pressure in foot deformities or tight shoes.
- *History*: Local pain and stinging pain in the case of clavus, especially plantar as well as at the dorsal foot over the contracted joints in hammer or claw toes.
- *Examination*: Localized swelling (Fig. 3.40). Tenderness to pressure, severe in case of clavus.

■ *Pes Planus (Flatfoot)*

Pes planus is a collective term for a pronation deformity of the foot. It involves the development of a foot deformity in various phases of life.

Congenital planovalgus foot

Congenital flatfoot with a malpositioned talus that can be radiologically visualized (talus verticalis). Depending on severity, other terms are also common. Rare.

- *Etiology*: Unclear. The following hypotheses are being discussed: combined deformity, abnormal position in utero, bony dystopia, neuropathy, and deformities based on inhibition and endogenous causes.
- *History*: Often in combination with other malformations, foot deformities and stumbling are commonly observed in children.
- *Examination*: Convexly bent foot sole. Pronation of the heel. Pronation and abduction of the forefoot. Deep skin folds in front of and behind the lateral malleolus. No change in form by strain. The feet are externally rotated when walking. Mobility in the foot is rigid.
- *Diagnostics*: X-ray of the foot in two planes. In sideward imaging, a talus verticalis becomes visible.
- *DD*: Acquired pes valgus and pes planus. Overcorrected clubfoot.

Acquired pes valgus and pes planus in childhood

Pes valgus and planus in children that presents when the child starts to walk.

- *Etiology*: Unclear. Patients with valgus and varus deformities in the knees are more susceptible and these deformities may be related.
- *History*: Seen in tall, slim children that take part in little movement or sport as well as in shorter, squatter but active children. Mostly visible in the flattened longitudinal arch of the foot and the increased valgus positioning of the heel. No pain.
- *Examination*: Internally rotated lower leg, increased valgus position of the heel, flattened longitudinal arch, and forefoot abducted and pronated. When the patients stand on their toes, they can either actively rise (Fig. 3.32, balanced deformity) or cannot actively rise (fixed deformity).
- *Diagnostics*: X-ray of the foot when standing in two planes and diagonally in case of a fixed deformity (talocalcaneal angle may be reduced). Podography (flattened arch).
- *DD*: Flatfoot in childhood (can be actively compensated when standing on the toes and passively).

Flatfoot of the adolescent

Pes planovalgus in adolescence.

- *Etiology*: Unclear. May be due to excessive strain or as a consequence of childhood flatfoot.
- *History*: Almost exclusively presents in puberty. Mostly bilateral, often a slight pes planovalgus. Sudden, severe pain following the lightest of movement and immobility in the subtalar joint.
- *Examination*: Valgus position of the heel, longitudinal arch flattened, and forefoot abducted and pronated (Fig. 3.33). Severe pain when testing mobility of the subtalar joint. Guarding of the peroneal muscles when testing the mobility of the subtalar joint. Immediate pain relief by local anesthetic injection. Eversion/inversion completely limited.
- *Diagnostics*: X-ray of the foot when standing in two planes and diagonal (talocalcaneal angle may be decreased, degenerative changes to the subtalar joint). Podography (flattened foot arch).
- *DD*: Arthritis (tuberculosis, beginning chronic polyarthritis).

Pes planus of the adult

Fixed pes planovalgus with degenerative changes to the tarsal bones.

- *Etiology*: Always the end result of childhood or adolescent pes planus. Also seen in overweight patients (excess load pes planus). Exogenous causes: post-traumatic (calcaneal fracture), scar tension following burn wounds, Sudeck's disease, compartment syndrome, paresis, polio, and rheumatoid arthritis.
- *History*: Strain-dependent pain without any correlation to the extent of the pes planus. Deformity and increasing limitation of mobility.
- *Examination*: Patient walks with the feet pointed outward, valgus position of the heel, longitudinal arch flattened, and forefoot abducted and pronated. Initially the patient is still able to actively rise on his feet (Fig. 3.32, balanced deformity), and in advanced cases, the foot cannot be raised actively or passively (fixed deformity).
- *Diagnostics*: X-ray of the foot in standing in two planes and diagonal imaging (talocalcaneal angle could eventually be reduced with degenerative changes to the subtalar joint). Podography (flattened arch of the foot).

Pes Cavus

Describes the short, plump foot with a high longitudinal arch. A dynamic deformity characterized by a disturbed muscular equilibrium. Associated with claw toe deformity.

One distinguishes between pes cavovarus (more common) and pes calcaneovarus. Pes cavovarus is characterized by excessive plantar flexion of the first metatarsal bone. Pes calcaneovarus is characterized by a dorsiflexed calcaneus and a plantarflexed forefoot. Pes cavus in children is still flexible and only turns into contracture later on. Depending on the flexibility, one further distinguishes flexible pes cavus and contract, painful pes cavus.

- *Etiology*: Rarely congenital. Mostly idiopathic. Mostly presents in patients with an upright gait. Also seen in neuropathic clubfoot (Friedreich ataxia, cerebral paresis, polio, encephalitis among others), as myelodysplastic pes cavus in myelodysplasia or spina bifida occulta. Less common as traumatic pes cavus following Sudeck's disease, freezing injury, or burns.
- *History*: Family-associated increased prevalence. Especially seen in athletic men and also in patients older than 30 and patients that place the most weight on the outside margin of the foot.
- *Examination*: Severely heightened longitudinal arch of the foot (Fig. 3.35), the heel is often fixed in a varus position, callus is seen on the outer margins of the foot, and in some cases severe claw toes. Callus and clavus at the sole of the foot and under the metatarsal bone heads as well as dorsally over the interphalangeal joints showing limited dorsiflexion.
- *Diagnostics*: X-ray of the foot in two planes (increased plantar flexion, the first and the fifth metatarsal bone overlap). Podography (heightened arch).
- *DD*: All etiologically relevant disorders.

High-Arched Foot

To be distinguished from pes cavus. A high-arched foot that is still normal.

- *Etiology*: Unknown. Most likely a normal variation.
- *History*: Barely any influence on performance. Pain is felt upon strain only when ill-fitting shoes are worn.
- *Examination*: Longitudinal arch barely altered, high dorsal foot. The heel shows a normal position.
- *Diagnostics*: Eventually X-ray of the foot in two planes (to rule out differential diagnoses). Podography (differential diagnosis).
- *DD*: Pes cavus

Drop Foot

Contracture involving the plantar flexion of the foot.

- *Etiology*: Contracture resulting from a drop foot, spastic paralysis with imbalance in favor of the calf muscles. In rare cases congenital. Occurs as an associated component in cases of clubfoot and also seen in bedridden patients.
- *History*: The affected foot cannot be actively lifted.
- *Examination*: Drop foot gait, high-standing heel, and plantarflexed foot. Lifting the foot is neither actively nor passively possible.
- *Diagnostics*: X-ray of the foot in two planes (to rule out changes to the bone). Neurological consultation (EMG, nerve conduction velocity).
- *DD*: All etiologically relevant disorders.

Pes Transversoplanus

Reduction of the transverse arch of the foot with extension of the forefoot by spreading of the toes. Leads to pathological strain on the second and third metatarsal heads. Associated with secondary deformity of the toes: hallux valgus, digitus quintus varus superductus, clawing, and hammer toes.

- *Etiology*: Laxity of ligaments and hormonal changes (pregnancy, menopause). Risk factors: obesity, high-heeled shoes, pes planus, pes cavus, and polyarthritis.
- *History*: More common in women. Pain at the forefoot (metatarsalgia). Strain-dependent when walking and standing and improves at rest.
- *Examination*: Spreading and loosening of the forefoot. Flattened transverse arch (podography). Plantar callus or clavi over the metatarsal bones. Localized tenderness. If combined with pes planus, an additional bunion and hammer toes may be seen. If combined with pes cavus, clawing and digitus quintus superductus may be seen (Fig. 3.39). Passive redression of the transverse arch by putting pressure with the hand on the metatarsal bones is not possible in case of contractured pes transversoplanus.
- *Diagnostics*: X-ray of the forefoot in two planes when standing (determining the tarsometatarsal and the intermetatarsal angle). Podography (flattened arch).

Bunion

Lateral deviation of the big toe at the metatarsophalangeal joint. Associated with internal rotation of the big toe and eventually with a metatarsus primus varus. Often bilateral.

- *Etiology*: Congenital epiphysis disorder (rare), mostly due to secondary strain-dependent deformity in pes plano or transversoplanus. Ligament laxity, post-traumatic, following inflammation, in rheumatoid arthritis, and paralysis.
- *History*: Mostly affects women, especially in adult age, tight shoes, excess strain, pain at the big toe, and swelling and redness at the big toe. Often associated with deformity of the second to fifth toe.
- *Examination*: Mostly a drop foot, combined with toe spreading and with bunion (Fig. 3.37). Medial pseudoexostosis (prominent first metatarsal head), in part local callus, redness, serous, or putrid secretion is possible. Often associated with hammer toe and claw toe, the big toe often covers the second toe (Digitus II superductus or infraductus).
- *Diagnostics*: X-ray of the forefoot in two planes when standing (determining the tarsometatarsal, intermetatarsal, and hallux abducto valgus angle).
- *DD*: All etiologically relevant disorders. Hallux rigidus. Gout. Köhler's disease.

Hammer Toes and Claw Toes

Contracture at the metatarsophalangeal or phalangeal joints of the second to fifth toes. Hammer toes are the most common.

- *Etiology*: Mostly secondary in pes planus, pes cavus, or combined deformity. Seen in rheumatic disorders, Sudeck's disease, and paralysis. Common causes include wearing high heels that are too tight. The congenital claw toe, affecting the second toe, is rare.
- *History*: Pain at the forefoot and at the callus and clavi. The hammer toe is common in combination with bunion, and the claw toe is common in combination with pes cavus. Mostly affects all toes (2–5).
- *Examination*: The affected joints are initially passively correctable. In the course of the disease, they become contractured.
  Hammer toe: Flexion contracture in the distal interphalangeal joint or (less commonly) in the proximal interphalangeal joint (Fig. 3.34). Dorsal callus over the contracture joint and plantar at the metatarsophalangeal joint.
  Claw toe: Dorsiflexion at the metatarsophalangeal joint, plantar flexion contracture in the proximal interphalangeal, and dorsiflexion contracture in the distal interphalangeal joint (Fig. 3.38). Callus at the proximal interphalangeal joint and over the toe tips and metacarpophalangeal joints is common.
- *Diagnostics*: X-ray of the forefoot in two planes (subluxation and dislocation of the toes in the metacarpophalangeal joint, ankylosis).

Dorsal Exostosis

Circumscribed bony prominence at the dorsal foot between the first cuneiform bone and the first metatarsal bone, less commonly also the navicular bone. Rare.

- *Etiology*: Often not actual exostosis.
- *History*: Pain at the dorsal foot via pressure from tight shoes.

- *Examination*: Palpable prominence at the dorsal foot, local redness and slight swelling possible, and local tenderness.
- *Diagnostics*: X-ray of the foot in two planes (to visualize exostosis, differential diagnosis).
- *DD*: Arthrosis in the joint between the first cuneiform bone and the first metatarsal bone (osteophytes), ganglion cyst of the talonavicular joint, and talus osteophyte.

Haglund's Deformity

Form variation of the calcaneal bone with a prominence at the cranial, posterior, and lateral margin of the calcaneal tubercle. Often associated with bursitis at the insertion site of the Achilles tendon.

- *Etiology*: Mechanical strain due to tight shoes.
- *History*: Heel pain when walking.
- *Examination*: Prominence of the heel at the insertion site of the Achilles tendon, local redness, local tenderness, and coarsening of the skin. Swelling and callus and pain exacerbation during active and passive dorsiflexion.
- *Diagnostics*: X-ray of the dorsal foot (to visualize exostosis).
- *DD*: Achillodynia. Ossified periostitis.

Calcaneal Spur

Reactive ossification in the form of a spur. Commonly at the medioplantar side of the calcaneus, toward the toe (lower calcaneal spur). Less commonly as dorsal calcaneal spur in the Achilles tendon. Mostly begins as an insertion tendinopathy.

- *Etiology*:
  Lower calcaneal spur: Chronic strain at the insertion site of the small foot muscles and the plantar aponeurosis. Negatively influenced by a flattening of the longitudinal arch of the foot, e.g., in pes planus.
  Dorsal calcaneal spur: Insertion site tendinopathy of the Achilles tendon.
- *History*: Strain-dependent, stinging pain under the sole of the foot.
  Lower calcaneal spur: Mostly older patients and/or patients with jobs involving long periods of standing or that are overweight.
  Dorsal calcaneal spur: Especially common in athletes or runners.
- *Examination*: Local tenderness to pressure at the heel (medial margin at the calcaneal tubercle).
- *Diagnostics*: X-ray of the dorsal foot (to visualize the calcaneal spur).
- *DD*: Insertion site tendinopathy (achillodynia). Specific or nonspecific inflammation (bone, joints, soft tissue). Chronic polyarthritis. Bechterew's disease. Gout. Diabetic polyneuropathy. Tumors (cyst at the calcaneal bone).

Chronic Ligament Instability At the Ankle

Instability mostly affecting the lateral ligaments. Can lead to secondary arthrosis.

- *Etiology*: Consequence of a lateral ligament rupture, especially when this is not recognized or not treated properly.
- *History*: Uncertainty when walking, especially on uneven surfaces, twisting the ankle, strain-dependent pain, and feeling of instability.
- *Examination*: Local tenderness to pressure at the anterior fibulotalar ligament. In some cases, a palpable gap is present there with increased anterior translation of the talus (Fig. 3.43) and in some cases increased inversion and increased lateral instability (Fig. 3.42, relatively difficult to differentiate). Always test both sides and compare.
- *Diagnostics*: X-ray of the ankle (stress imaging, increased lateral instability).
- *DD*: Constitutional laxity of the ligaments.

Plantar Fibromatosis (Ledderhose's Disease)

Contracture of the plantar aponeurosis. Mostly presents in a nodular form, less commonly covers larger surfaces. Also referred to as Dupuytren's contracture of the foot. Rare. High risk of recurrence.

- *Etiology*: Unknown.
- *History*: Common in combination with Dupuytren's contracture in the hand. Pain in the midfoot, especially when placing weight on the foot, but also at rest.
- *Examination*: Stringlike and in part nodular lump under the skin of the sole. Mostly plantar medial under the longitudinal arch, but also under the metatarsal bone heads. Rare under the lateral margin of the foot extending into the dorsal foot.
- *Diagnostics*: X-ray of the foot in two planes (to rule out pathological changes to the bone).
- *DD*: Soft tissue tumors. Foreign body.

- **Congenital malformation and metabolic disorders**

Accessory Bone in the Foot

Segmentation of the foot bones. Relatively common, but mostly an incidental finding. Mostly symmetrical.

- *Etiology*: Ossification disorder, spontaneous fracturing, fatigue fracture, avascular necrosis, and Köhler's disease.
- *History*: Spontaneous and strain-dependent pain between the age of 25 and 40.
- *Examination*: Localized and slight swelling. Prominence and tenderness to pressure.
- *Diagnostics*: X-ray of the foot in two planes (proof of the accessory bone, differential diagnosis).
- *DD*: Arthrosis. Late conditions following fracture or avascular necrosis of the bone. Metastasis.

Tarsal Coalition

Synostosis of the tarsal bones. One distinguishes among calcaneonavicular coalition, talocalcaneal coalition, and talonavicular coalition (rarest).

- *Etiology*: Familial disposition, in 80 % of cases presents bilaterally. Two theories: Fusion of the bones of the tarus and lacking segmentation of the primitive mesenchyma.
- *History*: Conspicuous as a rigid combined deformity of talipes valgus and pes planus.
  Calcaneonavicular coalition: Functional loss barely noticed. Pain only sets in with dysfunction and beginning arthrosis of the neighboring joints. Mostly begins in school-age children and then mostly as a strain-dependent pain.
  Talocalcaneal coalition: Strain-dependent pain, partly cramp-like pain at the peroneal muscles
  Talonavicular coalition: Relatively little pain upon strain.
- *Examination*:
  Calcaneonavicular coalition: Varus and pes planus deformity. Shaking movement possible when pronation–supination is attempted; in course the foot is fully fixed.
  Talocalcaneal coalition: Valgus position of the heel, limited inversion.
  Talonavicular coalition: Severe valgus in the heel, pronation and supination impossible.
- *Diagnostics*: X-ray of the foot in two planes (to visualize the coalition).

Congenital Pes Adductus

Adduction position of the forefoot that involves the single metatarsal bones, increasing in severity from lateral to medial. The hindfoot is increasingly fixed in the valgus position. The longitudinal arch is flattened. The adduction deformity increases with age.

- *Etiology*: Unknown. A genetic component is under discussion.
- *History*: Boys are more commonly affected than girls. Mostly bilateral, in many cases already visible after birth. Children often fall over their own feet as soon as they start walking.
- *Examination*: In light cases, only the big toe is fixed in the adduction position (hallux varus), otherwise typical adduction deviation of the forefoot (metatarsus adductus) (Fig. 3.34). With increasing deformity, the lateral part of the dorsal foot appears elevated, whereas the longitudinal arch is flattened (similarity to pes planus). The heel is in the neutral or valgus position. Callus can be found laterally at the sole over the cuboid bone. Deformity can be partly compensated or not at all (tested by the examiner holding the cuboid bone and the heel with one hand and exerting pressure on the medial longitudinal arch with the thumb of the other hand).
- *Diagnostics*: X-ray of the foot in two planes (to visualize the deformity and its extent).
- *DD*: Clubfoot. Inward gait in case of coxa antetorta.

Pes Calcaneus Congenitus

Clear dorsiflexion of the foot. The dorsal foot can touch the tibia. The heel is the most distal point of the foot.

- *Etiology*: Not clear. The following hypotheses are under discussion: intrauterine injury and dominantly inherited malformation syndrome (combination with spina bifida occulta and other foot deformities among others). Imbalance of the foot plantar flexors and the foot dorsiflexors.
- *History*: The foot of the neonate appears like a case of pes planus and is extremely dorsiflexed in the ankle.
- *Examination*: Extremely dorsiflexed foot. When testing passive dorsiflexion, the dorsal foot can touch the tibia. Plantar flexion is neither passively nor actively possible.
- *DD*: The so-called heel–foot position (disappears spontaneously or following a short redressing treatment).

Congenital Clubfoot (Talipes Equinovarus)

Complex foot deformity with the following component: drop foot, varus of the heel, as well as adduction of the forefoot and the hollow foot (pes adductus supinatus excavatus). In 0.1% of all neonates.

- *Etiology*: Unclear. Multifactorial, eventually polygenetic, and latently recessive inheritance.
- *History*: Two times more common in boys than girls. In 50% bilateral. The four key components of the clubfoot are already conspicuous immediately after birth.
- *Examination*: In 90° flexion of the knee and hip joint. Drop foot with high-standing calcaneal tubercle that is not correctable manually. Varus position of the hindfoot and adduction in the midfoot and forefoot. Supination of the complete foot (Fig. 3.36). Pes excavatus is not always easily spotted (subcutaneous fat). In the course of the disorder, atrophy of the calves sets in.
- *Diagnostics*: X-ray of the foot, eventually including the ankle in two planes, but only after the newborn baby's first birthday (control, talus–calcaneus angle).

In 5% of cases, associated deformity or dysplasia exists that need to be checked for (hip dysplasia leading to possible hip dislocation, spina bifida occulta, arthrogryposis, and neurological deficits).

- *DD*: Clubfoot position (can be corrected manually). Teratogenic (arthrogryposis), neurogenic (meningocele, cerebral paresis, myelodysplasia), and acquired post-traumatic or inflammatory clubfoot.

Polydactyly

Excess toes

- *Etiology*: Autosomal dominant inherited deformity.
- *History*: Mainly a cosmetic issue, but could eventually be troublesome when wearing shoes.
- *Examination*: Excess toes on the side of the big toe, the small toe, or centrally as a doubling of one of the smaller toes. Affects the distal and medial member of the toe or the whole toe.
- *Diagnostics*: X-ray of the forefoot in two planes when standing (to visualize the osseous malformation).

Syndactyly

Incomplete separation or differentiation of the toes.

- *Etiology*: Congenital.
- *History*: Harmless. Mostly neither cosmetically nor functionally problematic.
- *Examination*: Toes connected close to the metacarpophalangeal joint or only at the distal joints.
- *Diagnostics*: X-ray of the forefoot in two planes when standing (to rule out osseous malformation).

Digitus Quintus Varus Superductus

Varus of the small toe that leads to overlapping the fourth toe.

- *Etiology*: Congenital. Diagonal position of the metatarsal bone head.
- *History*: Problems with wearing shoes (shoes feel too tight), in some cases irritation.
- *Examination*: Mostly bilateral. The fifth toe is externally rotated and adducted, laying over the fourth toe (Fig. 3.39).

Avascular Osteonecrosis

Köhler's disease I

Spontaneous avascular necrosis of the navicular bone. Similar course of disease as in Perthes disease over the course of 2 years.

- *Etiology*: Unclear. Short perfusion interruptions are being discussed as well as excess strain.
- *History*: School-age children (most at the age of 6). Boys are affected twice as often as girls. In 30% of cases bilateral. Pain upon strain, in part swelling at the affected parts of the foot.
- *Examination*: Guarding limping. When walking, weight is placed on the lateral margin of the foot and rolling is carefully performed. Slight local swelling over the navicular bone is possible, localized tenderness.
- *Diagnostics*: X-ray of the foot in two planes (in the initial stage, relatively nonspecific). MRI (to visualize the necrosis).
- *DD*: Acquired childhood pes varoplanus. Less common: Osteomyelitis, tuberculosis, and tumors.

Köhler's disease II

Avascular necrosis of the juvenile metatarsal bone heads of the second, third, and fourth toe. Almost always leads to arthrosis of the affected joint.

- *Etiology*: Not clear. Short perfusion interruptions are being discussed as well as excess strain.
- *History*: School-age children and youths (most between the ages of 12 and 18). Four times more common in boys than girls. Localized strain-dependent pain (when rolling the foot) and dorsal swelling at the forefoot.
- *Examination*: Painful limping. Often pes varus. Localized dorsal tenderness over the metatarsal bones. Toe contracture in older findings.
- *Diagnostics*: X-ray of the forefoot in two planes (to visualize the necrosis).

Osteochondrosis dissecans tali

Osteochondronecrosis of the talus. Mostly affects the medial talus.

- *Etiology*: Unclear. Trauma is being discussed.
- *History*: Strain-dependent pain at the ankle, recurring swelling, and impingement syndromes (if a free-moving dissection is present).
- *Examination*: Swelling of the ankle and tenderness over the medial, anterior joint space. Painful impairment of mobility.
- *Diagnostics*: X-ray of the ankle in two planes, eventually MRI (to visualize the necrosis).
- *DD*: Flake fracture.

■ Gout (Podagra)

Uric arthritis of the metatarsophalangeal joint. Initially, gout mostly only affects one joint, in rare cases a few joints. Only in chronic gout does the disease affect several joints (polyarticular). The big toe is the most common location for an acute inflammatory gout attack. In chronic inflammatory cases, gout can lead to joint destruction.

- *Etiology*:
  Primary: Purine metabolism disorder caused by a genetic defect, involving reduced renal excretion of uric acid or increased synthesis. Mostly induced by overeating.
  Secondary gout is seen in hematological disorders involving cell destruction or disorders involving renal function impairment.
- *History*: Typically presents in flares. The acute inflammatory change in the metacarpophalangeal joint is very typical. Causal factors: Consumption of fatty foot, alcohol, trauma, or surgery. Patients often report that they cannot cover the big toe with bedsheets anymore, as this is too painful. Patients do have symptom-free intervals that become shorter if the disease is left untreated.
- *Examination*: Local redness and swelling of the big toe's tarsometatarsal joint. Tenderness to pressure and movement in the joint.
- *Diagnostics*:

Blood tests: Leukocytosis, slightly elevated erythrocyte sedimentation rate (ESR) and elevated uric acid levels in plasma (hyperuricemia). In chronic gout, X-ray of the forefoot in two planes (visualizing the joint space and the joint surfaces).

- *DD*:
  Acute gout attack: Pseudogout (calcium pyrophosphate gout) and acute rheumatoid arthritis.
  Chronic gout arthritis: Hallux rigidus, chronic polyarthritis, and diabetic arthropathy.

■ Diabetic Osteoarthropathy (Diabetic Foot)

Relatively rare arthropathy mostly affecting the skeletal foot. Even less common in the ankle or the knee. At the foot, the disorder is recognized by diabetic angiopathy, polyneuropathy, osteolysis at the metacarpal bones, spontaneous fracture of the tarsus bones, joint effusion, and massive joint destruction with dislocation and subluxation. Neuropathic ulceration, in course also ischemic-gangrenous ulceration.

- *Etiology*: The polyneuropathy is seen as the key factor.
- *History*: Can appear about 2 years after the diagnosis of diabetes is made. Diffuse, in the course of disease, circumscribed pain-free swelling of the foot, spontaneous fracture, and dislocation/subluxation. Deformity in the foot, burning sensation at the sole of the foot ("burning feet"), and restless legs and feet, especially at night also disturbing sleep: Typically movement improves the restlessness. Calf pain and, especially at night, sensory function problems, mostly unilateral and especially affecting the distal foot. Ulceration at the forefoot (malum perforans) in cases of reduced ability to sense pain (hyperesthesia) and dry or moist gangrene that is mostly painful. Secondary infection is possible.
- *Examination*: Diffuse or circumscribed swelling of the foot. Pes planus (in subluxation and dislocation as well as in spontaneous fracturing). Plump feet (in cases of destruction). Calf tenderness. Socklike circumscribed paresthesia (distal symmetric), reflexes (Achilles tendon reflex, ◘ Fig. 1.42; quadriceps reflex, ◘ Fig. 1.41)

decreased. Malum perforans (barely any pain). Mostly absent pulse in the feet.
- *Diagnostics*: X-ray of the foot in two planes, MRI (to visualize the damage to bones and joints). Angiography. Swab with microbiology.
- *DD*: Ischemic gangrene in peripheral artery disease. Osteomyelitis. Psoriatic arthritis. Tabes dorsalis. Syringomyelia. Tumors.

- **Degenerative disorders**

Arthrosis of the Ankle

Degenerative disorder of the ankle.
- *Etiology*: Mostly post-traumatic, also secondary following inflammation.
- *History*: Warm-up or strain-dependent pain. Swelling upon excess strain.
- *Examination*: Eventually swelling at the ankle. Tenderness to pressure over the anterior joint space (painful) and limitation of mobility (Figs. 3.41 and 3.42).
- *Diagnostics*: X-ray of the ankle in two planes (visualizing the joint space and surfaces).

Hallux Rigidus

Arthrosis of the big toe metatarsophalangeal joint. Mostly unilateral. Can be combined with a hallux flexus.
- *Etiology*: Mostly unclear. Secondary post-traumatic, following inflammation and in rheumatoid arthritis.
- *History*: *Most* common in men. Pain at the big toe metatarsophalangeal joint upon strain, especially when walking. Patients walk with adducted legs and roll their feet over the external margins of the foot.
- *Examination*: Metatarsophalangeal joints mostly swollen, local tenderness to pressure and touch. Dorsiflexion is painfully limited. In the course of disease, flexion contracture in the distal joint (hallux flexus).
- *Diagnostics*: X-ray of the forefoot in two planes when standing (visualizing the joint space and surfaces).
- *DD*: Uric arthritis (attack-like, severe pain).

- **Inflammatory disorders**

Nonspecific Inflammation

Unguis incarnatus

Ingrown toenail. Mostly the big toe is affected.
- *Etiology*: Side pressure against the nail, leading to an inflammation. Commonly aggravated by tight shoes.
- *History*: Inflammatory changes to the lateral nail.
- *Examination*: Redness and swelling over the lateral nail. Often combined with a putrid secretion. The nail is often thickened and rolled in on the side. Local tenderness.

Rheumatic Inflammation

Rheumatic foot

Includes deformation changes to the whole foot.
- *Etiology*: Chronic rheumatoid inflammatory process.
- *History*: Associated with a valgus/pronation deformity due to the progressive destruction of the joints. An inflammatory foot develops with hallux valgus, subluxation, and dislocation of the tarsometatarsal joints of the second to fifth toe. Callus is found on the feet. Infection at the pseudoexostosis of the big toe's tarsometatarsal joints possible.
- *Examination*: Severe valgus and drop foot, hallux valgus (Fig. 3.37), claw, and hammer toes (can be compensated, partly fixed, contractured to fixed). Plantar callus under the metatarsal bone heads and dorsal callus under the toe joints. Medial pseudoexostosis and eventually redness. In occasional cases, a serous or putrid secretion may be present.
- *Diagnostics*: X-ray of the foot in two planes (to visualize the tarsometatarsal, intermetatarsal, and hallux valgus angle). Eventually podography (reveals a flattened arch).
- *DD*: Psoriasis arthritis. Post-traumatic foot deformity.

- **Traumatic disorders**

Peroneal Tendon Dislocation

Dislocation of the peroneal muscle tendon from its bed over the lateral malleolus in a anterolateral direction. Caused by injury to the superior retinaculum (bending or loosened with the periost of the lateral malleolus). Patients present with acute or chronic peroneal tendon dislocation.
- *Etiology*: Sudden passive dorsal extension and eversion of the foot (e.g., anterior fall when skiing).

- *History*: Painful, recurring snapping of the peroneal tendon over the lateral malleolus. Can be elicited spontaneously.
- *Examination*: Swelling in front of the posterior parts of the lateral malleolus. Localized tenderness. Dislocation phenomenon in passive and active dorsiflexion is palpable, partly palpable crepitation.

Achilles Tendon Rupture

Rupture of the Achilles tendon. Often overlooked in the acute stage!

- *Etiology*: Degenerative changes to the tendon. Local steroid injection.
- *History*: Following sudden muscle contraction, acute pain presents. Patients describe the sensation "as if someone has just kicked me in the calves." Normal walking is not possible.
- *Examination*: Limping gait. Palpable gap in the course of the Achilles tendon, about 4–6 cm above the ankle. Positive Thompson test (Fig. 3.34). Active plantar flexion (standing on the tips of the toes) not possible.

External Ligament Rupture

Injury to the external ligaments at the ankle, mostly the anterior fibulotalar ligament. One distinguishes among distortion, hyperflexion, part rupture, and rupture. Furthermore, isolated and combined as well as new and old rupture.

- *Etiology*: Supination trauma (soccer, volleyball).
- *History*: Often an audible and sensed loud sound when twisting the foot, increased swelling, and pain. Walking is impaired by the pain.
- *Examination*: Swelling of the lateral ankle, hematoma, local tenderness to pressure, mobility is limited by the pain. Pain exacerbation by forced passive inversion, eventually increased lateral instability, increased anterior translation of the talus in comparison to the opposite foot (Fig. 3.43, cannot always be shown, as the patient is often too tense due to fear and pain).
- *Diagnostics*: X-ray of the ankle in two planes (a.p. in 15° internal rotation). As soon as a fracture can be ruled out, X-ray imaging under varus stress (lateral instability) and under anterior translation of the drawer phenomenon is performed.
- *DD*: Ankle fracture.

In these injuries, the examiner must always first look for a possible ankle injury, before further imaging is performed. X-ray imaging often is performed while exerting stress on the lateral ligament: either in form of anterior translation in the drawer phenomenon or in form of lateral instability stress. Nonetheless, it is crucial to first perform X-ray imaging in two planes to rule out fracture; otherwise, dislocation may be induced.

Syndesmosis Rupture

Rupture of the anterior fibulotalar ligament and the interosseous membrane. Mostly combined with a Weber C or Maisonneuve fracture.

- *Etiology*: Supination–external rotation trauma.
- *History*: Swelling at the anterior syndesmosis ligament (only in the first 24 h). Pain at rest and upon strain.
- *Examination*: Pain during eversion of the foot, not during inversion. Pain exacerbation by compression of the fibula against the tibia. To test syndesmosis stability, the lateral malleolus is anteriorly and dorsally fixed, and translation in an anterior–posterior direction is performed. An increased instability is a sign for injury to the syndesmosis. The opposite side should be used as comparison. The damage to the syndesmosis can be tested by revealing tenderness anterior and dorsal to the lateral malleolus (Fig. 3.45). A high fibula fracture must be ruled out. The fibula must be palpated (Fig. 3.46).
- *Diagnostics*: X-ray of the ankle in two planes (to rule out fracture and diastasis, the talus moves between the fibular and the tibia).
- *DD*: Ankle fracture (Weber C or Maisonneuve).

Ankle Fractures

Fractures in adulthood or childhood. Categorized according to Danis–Weber depending on the height of the fibula fracture. Associated with injury to the medial and lateral ligaments. Further associated fractures of the proximal fibula (Maisonneuve fracture) and at fractures at the base of the fifth metatarsal bone should not be missed. Epiphysis injuries are classified according to Salter–Harris into type I to V, depending on the injury.

A further special group of ankle fractures following a vertical blow to the ankle are the so-called compression injuries. Classic form is the pilon tibial fracture.

- *Etiology*: Mostly following an indirect trauma. Inversion or eversion trauma. Compression injuries occur in cases of falling from a higher elevation or following severe dorsiflexion of the foot.
- *History*: Acute pain, severe swelling, and inability to walk or stand.
- *Examination*: Severe swelling at the ankle, hematoma, and tenderness to touch and pressure. In case of fracture of the fifth metatarsal bone, tenderness to pressure can present (Fig. 3.47).

Ankle injuries should always be clinically examined at first. In case of a dislocation or subluxation of the ankle, the joint needs to be relocated immediately.

- *Diagnostics*: X-ray of the ankle with the lower leg in two planes (to visualize the fracture).

Talus Fracture/Talus Dislocation

Divided into central fractures (*necrosis is possible*) *and peripheral fractures* (*necrosis is not possible*).

Fractures of the talus neck are the most common form of severe talus injury. Depending on the dislocation of the fragments, talus neck fractures (*type I to IV according to Hawkins*) *are distinguished. One distinguishes comminuted fractures, fractures of the lateral talus process* and *of the posterior talus process, torsion fractures, and chondral fractures of the talar trochlea. In rare cases, talus head fractures as well as subtalar and total talus dislocation are observed. Mostly accompanies other fractures* (*tibial head, femoral neck, spine*).

- *Etiology*:
  Talus corpus fracture: Compromising forces.
  Talus neck fracture: *Mostly in a context of forced dorsal flexion* (e.g., *when powerfully operating the kick starter of a motorcycle, fall from a great height).*
- *History*: Swelling. Pain upon strain.
- *Examination*: Painful limping, swelling, and hematoma. Local necrosis of the skin is possible, tenderness, eventually palpable fragments. The mobility in the ankle is painfully limited, painful flexion of the big toe (in case of a fracture of the posterior talus process).
- *Diagnostics*: X-ray of the foot with the ankle in two planes. Eventually CT or MRI (to visualize the fracture and its extent).

A clear dislocation of the fragments is an emergency: *skin necrosis or talus necrosis may follow*! *Relocation needs to happen as soon as possible*!

Calcaneal Fracture

Fracture of the calcaneus. Most common fracture of all the tarsus bones. One distinguishes intra-articular (*70–80 %*) *and extra-articular calcaneal fractures. Commonly presents bilaterally or in combination with fractures in the legs and the spine* (*compression fracture*).

- *Etiology*: Rotation or sudden muscle contraction (especially in extra-articular calcaneal fracture) as well as in case of falling from a height greater than 1 m (attempted suicide, occupational, or sports injuries).
- *History*: Severe strain-dependent pain in the affected foot.
- *Examination*: The heel appears widened and shortened. Hematoma may be present in the heel, and eversion/inversion is limited, as well as dorsiflexion and plantar flexion (Figs. 3.41 and 3.42).
- *Diagnostics*: X-ray of the heel axially and from the side (to determine the fracture type, joint angles).

It is important to repeatedly check the sensory function on the plantar side of the toes and the position of the big toe. Hypesthesia and an increased flexion of the big toe are strong indications for compartment syndrome in the foot.

Fractures of the Metatarsal Bones

Rarely seen as avulsion fracture at the base of the first metatarsal bone. In the smaller metatarsal bones, often combined with severe soft tissue injury. A special form is the marching fracture.

- *Etiology*: Mostly direct or compromised trauma. Less common causes include twisting (inversion injury, e. g., simple stumble; affects the first metatarsal bone).
- *History*: Circumscribed strain-dependent pain. Swelling.
- *Examination*: Local swelling, hematoma, and tenderness. Flattening of the longitudinal arch when standing.
- *Diagnostics*: X-ray of the metatarsal bones in two planes (to visualize the fracture).

Marching Fracture

Fatigue fracture mostly in the distal third of the second or third metatarsal bone. Less common is the shaft fractures close to the base (Jones fracture).

- *Etiology*: Uncommon strain and load at the forefoot and excess strain (marathon runners, marching).
- *History*: Mostly delayed beginning of the strain-dependent pain. Increasing swelling of the dorsal foot.
- *Examination*: Swelling. Local tenderness to pressure.
- *Diagnostics*: X-ray of the forefoot in two planes (to visualize the fracture). Scintigraphy (positive from an early stage) or MRI (in continuing pain or negative X-ray).

Toe Dislocation and Fractures

Present as dislocated or non-dislocated fractures.

- *Etiology*: Mostly via direct, severe trauma. At the second to fifth toes either via a medial or lateral blow.
- *History*: Local pain and swelling.
- *Examination*: Local hematoma and swelling; in case of dislocation especially at the big toe, the skin can be relatively taut! Malposition of the foot. Localized tenderness to pressure and movement.
- *Diagnostics*: X-ray of the forefoot in two planes (to visualize dislocation or fracture).

- **Tumor disorders**

About 4% of all bone tumors and tumorlike bone lesions affect the foot. Almost all bone tumors can be found. Osteosarcoma is relatively common at the foot (about 75% or all bone tumors). Further common tumors at the foot include the calcaneal cyst (as tumorlike bony lesion) and the osteoid osteoma. Often an incidental finding in X-ray.

- *History*: Swelling, strain-dependent pain (in case of osteoid osteoma independent of strain).
- *Examination*: Local swelling (circumscribed or diffuse), eventually local tenderness to pressure.
- *Diagnostics*: X-ray of the foot in two planes (visualizing the herd is not always possible). Scintigraphy (visualizes an active process). MRI (to visualize the herd and its extent).

- **Neurological disorders**

Tarsal Tunnel Syndrome (Tibial Nerve; L4–S3)

Impingement syndrome of the posterior tibial nerve (proximal tarsal impingement) and its branches (the medial and lateral plantar nerve—distal tarsal impingement) under the muscular flexor retinaculum at the medial malleolus.

- *Etiology*: Direct compression, vascular insufficiency with ischemia, often trauma related (also further in the past) at the ankle, dilated veins, rheumatic inflammation at the ankle (tenosynovitis), muscle anomalies, and tumors.
- *History*: Pain, especially at the medial ridge of the foot radiating into the toes, the sole of the foot, the heel, and the calf. Dysesthesia and hypesthesia, burning paresthesia at the sole of the foot. These complaints are especially common at night.
- *Examination*: Local tenderness to pressure over the medial malleolus and positive Tinel's sign (compare ◘ Fig. 2.33) at the medial malleolus. Pain exacerbation by forced dorsiflexion and pronation. Hypesthesia at the medial foot. Local anesthetic injection alleviates pain immediately.
- *Diagnostics*: X-ray of the foot in two planes. Neurological consultation (EMG, nerve conduction velocity, new or old injury, denervation, repair).
- *DD*: Morton's metatarsalgia. Diabetic polyneuropathy.

Morton's Metatarsalgia

Paresthesia and pain at the forefoot. In 80% of cases between the third and fourth metatarsal bones.

- *Etiology*: Sclerotic thickening of the digital nerve (pseudoneuroma) as a consequence of compression between the metatarsal bones. Often due to too-tight, high-heeled shoes.
- *History*: Often in connection with hallux valgus and pes valgus. Burning or "electricity-like" pain and paresthesia at the forefoot especially following longer walking.
- *Examination*: Severe intermetatarsal tenderness to pressure. Pain when the neighboring metatarsal bones are rubbed against one

another (fixation with the thumb and the index finger of both hands—the so-called Hohmann grip). Local anesthetic injection offers pain alleviation within 1–3 h.
- *Diagnostics*: X-ray of the forefoot in two planes to rule out pathological changes to the bone.
- *DD*: Pes valgus. Inflammation. Marching fracture. Tumors.

■ *Drop Foot*

Consequence of a flaccid paralysis of the dorsiflexors of the foot.
- *Etiology*: Polio, peroneal nerve paresis, root lesion of L5 (e.g., motor root compression syndrome of L5 following disc herniation). Paraplegia following trauma.
- *History*: Active dorsiflexion of the foot not possible. Gait uncertainty.
- *Examination*: Drop foot (inability to dorsiflex the foot). Initially passive mobility in the ankle is possible, but not active dorsiflexion (Fig. 1.47). Untreated, passive dorsiflexion becomes impossible as well. Sensory disorders may present depending on the etiology.
- *Diagnostics*: X-ray of the foot in two planes, eventually of the knee, the pelvis, and the spine (depending on the etiology). Neurological consultation (EMG, nerve conduction velocity).

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